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CITY LIGHTING.

THE Anglo-American Brush Electric Light Corporation has taken advantage of a very favourable opportunity to once more impress upon the City Fathers the advantages of electric lighting for the City streets. The tragic occurrences—literally, deeds of darkness—in the East End, and in one eastern corner of the City itself, have roused the minds of the populace to the great need for the better lighting of the streets, squares, courts and alleys of the metropolis. This need has been strongly urged by correspondents of the daily newspapers, and the newspapers—the *Daily News*, notably—have themselves taken up the cry. In this connection and at this juncture, when the subject of electric lighting is once more prominently before the public, it is not surprising that electricity is pointed to as the most adequate means of illuminating the dark places of our City. If increased lighting is necessary, a greater expenditure is imperative, and the additional sum devoted to the purpose will be better spent in securing the electric light than in multiplying gas lamps. What is needed is as close an approximation as possible to the light of day, and the arc will achieve this end in a more satisfactory manner than any other illuminant. With these obvious arguments in mind, and with the view of emphasising its proposals already under the consideration of the Commission of Sewers, the Brush Company has issued for private circulation a historical *resumé* of past negotiations for electrically lighting the City, to which is added a very able statement of the present position of the electric lighting question.

It may be remembered that at one time Mr. W. H. Preece, who has throughout acted as technical adviser to the Commission, was an advocate of incandescent lamps for street lighting, allotting to the arc the illumination of large open spaces only. Mr. Preece has no doubt changed his mind upon that point since 1883, and it is pertinently pointed out by the Brush Company that the installations for street lighting by glow lamps upon which Mr. Preece's experience was founded, one on Holborn Viaduct and another at Wimbledon, both came into disuse within short periods of one another, and after trials which had not much more than a year's duration; allusion is also made to the unsatisfactory character of the Leamington glow lamp installation. Perhaps, had the Corporation delayed the issue of its circular for a few days, it might have been tempted to include in its list of glow lamp failures out of doors the recently opened installation at Barnet. As it is, however, a good case is made out for arc lighting in the streets as opposed to incandescent lighting. We have always held the opinion, and have frequently expressed it, that but little good is gained by substituting glow lamps for gas in the streets; if electric lighting is to be adopted at all, it is far better to make the whole plunge at once, and introduce the one form of illumination which is calculated to brilliantly light our thoroughfares, and to impress by the force of contrast. A strong point made by the advocates of the arc lamp is the reference to the testimony of the police of the United States, who regard the electric light as their best friend, inasmuch as it makes the commission of crime difficult and the detection of the criminal an easy matter. In view of recent horrors, this is a point which demands earnest attention, and this, we have no doubt, will be given by the Commissioners of Sewers. And while the public mind is still hot and fully alive to the necessity for more light, we hope the authorities outside the City boundaries will take into consideration the benefits which would be conferred upon their respective districts by the introduction of the arc lamp. "A city that is well lighted is well policed."

VOLTAGE OF INCANDESCENCE LAMPS.

MAKERS and users of incandescence lamps have, in the past, been equally interested in producing and obtaining lamps of high voltage, because such lamps reduced the difficulties of distribution. Indeed, there was a time—and not very long ago—when a good many competent electricians were looking for a solution of many difficulties in the direction of a gradual increase in the voltage at which lamps could be made. And there is no doubt that if lamps of low candle-power—that is 10 to 20 candles—possessing long life and high efficiency, could be economically manufactured to work at 200 to 300 volts, there would be an enormous impetus given to direct supply on the simple parallel or three-wire system. But as time went on it was found that lamps were not by any means showing any evidence of important advances in this direction. They remained almost stationary in character, and it began to be felt that it was unwise to build upon any radical improvement in this direction. As a matter of fact, the only advance in incandescence lamp manufacture has been in the production of lamps of large candle-power suitable for ordinary circuits of about 100 volts. Makers have learnt how to increase the power for low voltage but not the voltage for low powers, and we are not at this moment able to look in but one direction in which there is even a present hope of much more than this being done.

There is now really a movement in an opposite way—a result, to a certain extent, of the entirely altered aspect of distribution brought about by the recognition of the advantages of high tension alternate current supply by means of transformers. The difficulty of economically conveying the current to the lamps has been overcome, and attention is being turned to the second point, how best to run lamps so that their duration shall be considerable. The question of whether a high or a low voltage lamp was the better one came up in the course of a discussion at the British Association meeting, and received no definite solution. We think there can be no reasonable doubt that for many purposes a 50-volt lamp is better than one for a hundred volts. The former is a much sturdier article, and its filament will bear much more denudation than the latter before it gives way, or has to be removed. On the other hand, the blackening of the globe and the loss by conduction at the mounts are somewhat greater with the lower voltage filament.

Of course the real objection to reducing the voltage is to be found in the increased cost of conductors, but now that there are so many small and compact installations supplied by transformers on the spot, this increased cost will be found to be insignificant, or at any rate, will willingly be borne if it enables lamps to be used of greater durability than those at present chiefly employed. A year or two of experience will decide the point, and we draw our reader's attention to it to induce those who have the opportunity to collect *data* and compare their experience.

DR. A. DE WATTEVILLE, in a letter to Mr. Jerritt, says that his opinion on galvanic belts generally is to be found in the first edition of his "Medical Electricity." The public, he very truly states, *will* be quacked, and impostors are certain to get the best of discussions with scientific men who obviously cannot disprove the assertions contained in the showers of testimonials always at hand. This coincides exactly with the comments we made on the subject months ago.

THE eminent physician sympathises with any effort made to enlighten the victims of galvanic belt quackery, and we feel, therefore, that we have his moral support. But is it not time that others who have taken the matter up with the view of probing the whole matter to the bottom should bestir themselves? Letters to the REVIEW have been forthcoming *ad nauseam*, but something more than this is necessary to be of any real service to the public weal. Other methods of operation have for some months past been under weigh, but we see no signs at present that they are any nearer their ultimate end than when first broached.

Apropos of the excitement recently caused in commercial circles respecting electrically-refined sugar the following note, which appeared in the REVIEW for October 24th, 1884, may be interesting inasmuch as it clearly shows that the process appeared then to be in nearly as advanced a state as now. "A number of St. Petersburg capitalists have combined for the formation of a joint-stock company for refining sugar by the Friend electrical process. It is said to be beyond that the process will considerably reduce the cost of Russian refined sugar. It is proposed to erect mills for the purpose in St. Petersburg, Moscow, Odessa and Kieff." It seems to us that this item of stale news might with advantage be copied into financial papers.

THE Portuguese Government has granted to the West African Telegraph Company and to the Eastern and South African Telegraph Company an exclusive concession for 40 years authorising these companies to lay submarine cables along the West African Coast between St. Paul de Loanda and Cape Town, touching at the intermediate ports of Benguella and Mossamedes. These cables should be laid before the 30th September, 1889.

A WELL-KNOWN Professor and F.R.S., in a letter to us which is generally couched in complimentary terms, concludes thus :—"But why do you run down so mercilessly every untried invention, as you did with secondary generators and are now doing with phonographs? Why not encourage what is really good?" Now, we think that every unbiased person who himself wishes to see the electrotechnical industry progress by leaps and bounds, and free from anything approaching charlatanism, will give the REVIEW credit for having done much to sift the grain from the chaff. Our comments upon secondary generators were certainly not directed at the apparatus, but against those who wished to claim them as a perfectly new discovery. Certain doubtful data which resulted from their use upon the Underground Railway were also criticised, but we will not admit that we ever ran down secondary generators from the point of view which our correspondent has taken up. Why should the phonograph be called an untried invention? Judging from the pearls which fall from the lips of its representatives in this country, and which are re-echoed by the daily Press throughout the land, there is nothing under the sun which the phonograph has not accomplished or which it cannot be made to perform. Because our views do not exactly coincide with those who see money in anything which tickles the public fancy, we are considered merciless; but more mature reflection will, we think, convince our friend that the policy to which the REVIEW has so firmly adhered has, generally speaking, been found right in the long run. When it is thought that we have erred in our opinions our columns are always at the service of those who can advance counter arguments, so perhaps Professor —— will open the ball by showing us what there is to champion in the phonograph, always remembering, which perhaps he is now sometimes apt to forget, that what may be highly successful in America does not necessarily in the least degree answer English requirements or suit English methods of transacting business.

ONE of our contemporaries published last week a paper stated in a foot-note to have been read at the meeting of the British Association. As a matter of fact, it was not brought before the meeting at all, and that is the reason why it did not figure in our own pages, a copy of the MS. having been in our hands for some weeks.

A FRIEND writes :—"Mr. Preece seems to have brought about his ears the 'accountants of science,' *mathematicians pure and simple*. There is a lot of arrant humbug stowed away now and then under a mathematical cloak. Mathematics has its uses and abuses, but the development of the latter is by far the commoner. When some young shaver shoots off his school learning, I feel inclined to reply to him in Italian, as both are as generally and completely understood in the

Society of ——, and the latter would be a more ready means for me to personally explain what I wanted to say."

WE are given to understand that the Azores cable scheme is something not very real. In order to save the concession, which exacts that the cable should be landed in Portugal by the end of last month, some few miles of cable have been sent out in a cargo steamer, to be landed on Portuguese territory, as the first step towards completing the line from Portugal to America *viâ* the Azores. *Ce n'est pas fort*, as our French friend says.

LAST week we touched upon the probabilities of the commercial advantages offered by phonographic instruments, and in continuation of those observations we would point out that there would be a limit to the use of phonograms for legal purposes, at any rate until the present "improved" machines have made further advance towards perfection. The similarity of the sounds given out from the wax covered cylinders compared with those spoken in is not sufficiently distinct to admit of a certain recognition of the speaker's voice, and much legal phraseology would be expended in proving the authenticity of a wax replica, even if such unsworn evidence could be admitted to, say the Probate Court. Also as regards documents or deeds requiring to be stamped, of course phonograms would be impracticable. Therefore, seeing, as we have previously shown, that these graphs and phones are only likely to be useful for unimportant or ordinary transactions, a measure of their value could be readily computed by comparing the cost of the machines, and the advantages they give, with the cost of a shorthand writer and his services. An attendant must be available to take off and label the cylinders and to file them away when done with, for we must not simply take the case of one customer calling at a merchant's office and dictating his phonic message—which supposes the machine ready prepared for him—but consider that only such persons will buy phonic machines who have a considerable use for them. Again, at present, how many firms find a customer, in the absence of the responsible representative he wishes to see, request the shorthand writer to take down a communication to be read out to his principal? If the answer to this question be that such a transaction is extremely rare, there would appear to be no existing want felt for phonograms and their translators. Their introduction may, however, create a field for their employment, and, while we point out the directions in which their use is limited as a word of warning to prevent hasty conclusions, we should be glad to witness their development.

A DETERMINED effort is being made by Messrs. Lawrence, Paris and Scott to introduce the electric light into the borough of Ipswich, but they have not hitherto found the matter all plain sailing. They made application to the Paving and Lighting Committee last week to be permitted to take up footpaths in order to lay cables for electric light and power purposes, and, whilst their application was not refused, it met with a considerable amount of opposition. We learn from the *East Anglian Daily Times* that the Ipswich Corporation contains many gas shareholders, and that one of the principal objectors at the meeting of the Lighting Committee to the granting of Messrs. Lawrence, Paris and Scott's application, Mr. W. B. Jeffries, is a prominent shareholder in the local gasworks. Mr. Jeffries thought that the electric lighting firm should apply for a provisional order, but it was pointed out that it was quite within the right of the committee and the Corporation to grant all the powers that are necessary, and it would be only causing Messrs. Paris and Scott to incur much greater expense to drive them to the Board of Trade for a provisional order. The matter was ultimately left to the Chairman of the Committee, the Mayor, and two other councillors to consult with the Town Clerk and the Borough Surveyor and report to the next meeting. When that meeting comes we hope to learn that the gentlemen having the matter under consideration will prove themselves, whether gas shareholders or not, possessed both of wisdom and generosity.

THE circular which has been issued to the shareholders of the Anglo-American Brush Electric Light Corporation, Limited, and published on another page, is of an interesting nature. We have had filaments, such as are used in the "Victoria" incandescent lamp, submitted to our inspection, and we should not be at all surprised if everything claimed for these is perfectly justified. The filaments, indeed, are wonderful examples of strength, flexibility, and homogeneity.

MR. HAROLD P. BROWN defends himself very ably against Dr. Vander Weyde, and the latter must admit having got the worst of it, especially over the Cardew voltmeter squabble. The last paragraph but one in Mr. Brown's paper also shows that alternating currents have killed more than their due proportion of victims. We do not think, however, that his dog-killing experiments have brought to light anything which was not known, or, at least, suspected years since.

MR. MCCLUER'S experiences of the troubles caused in telephone circuits by the currents used to operate arc circuits and electrically-propelled tramcars are very readable, and although the time has not yet arrived when we in England are likely to be thus troubled, it will be well to remember this paper in the event of similar work being carried out here. The numberless worries and trials to which American electricians, through the very multiplicity of their operations, are subjected, and which they generally manage to finally overcome or reduce to a minimum, cannot fail to prove of service to our own countrymen.

TO-DAY, at 3 p.m., the meeting of the Organising Committee of the Electrical Trades Section, which it is proposed to associate with the London Chamber of Commerce, takes place. Doubtless before the end of the month a general meeting of the trade will be convened, and this we trust will be attended by everybod who can possibly make it convenient to put in an appearance.

DR. AUGUSTUS WALLER'S paper on the electromotive properties of the human heart ought to create a desire on the part of some of our electrical investigators to carry out further experiments in which our bodies shall play the most important *rôle*. Doubtless the medical profession generally would be grateful for assistance of this kind, for very few of them have either the time, the requisite electrical training, or the means to seek it for themselves.

THE WATERHOUSE AUTOMATIC REGULATOR.

IN the diagram is represented the Waterhouse type of dynamo, with a closed circuit armature, A. On the commutator, C, are three brushes; *a* and *b* are the main circuit brushes, and *c* the auxiliary brush. From the positive brush, *a*, the current passes on the conductor around the field magnets, F, to the resistance, R. The current from the auxiliary brush, *c*, passes directly to resistance, R, leaving the field magnets out of circuit. The current from both circuits (field and local) joins at R, and passes to the lamps, the current on the lamp line being the sum of the two. The amount of current in the field and local circuits is in proportion to the resistance, R, in each. The brushes have a fixed position.

There is in every dynamo a point of maximum commutation on the armature, which changes with the resistance on the lamp line, moving with the rotation (towards brush *c*) when the resistance decreases and back when it increases. This affects the current in the local and field circuits, as follows: When lights are turned out the line resistance is decreased, and the maximum point moves forward and forces more current out of brush *c*, and less out of brush *a*. This reduces the current in the field magnets and the E.M.F. of the circuit, and consequently the power required to operate the dynamo; but the current on the lamp line remains constant because the local circuit is increased proportionally to the decrease of the field circuit. The remaining lamps therefore retain their full brilliancy, while the current cannot increase and destroy the apparatus. Thus, the very tendency of the machine is to perfect regulation without the aid of mechanism, but when to this is added the simple regulator, which makes the regulation instantaneous by assisting the current to pass out at brush *c*, and opposing its passage around the field magnets by way of brush *a*, when lights are cut out, and forcing it out at brush *a* around the field magnets by opposing its passing out at brush *c* when lights are cut in, the efficiency of the method can be appreciated.

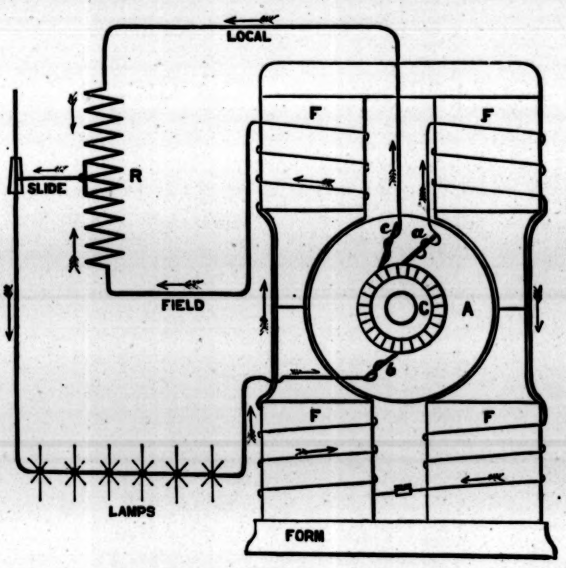

DIAGRAM OF WATERHOUSE DYNAMO.

The regulator is illustrated by the slide in the form which is controlled by a solenoid. Any tendency of the current to increase raises the slide (see slide in diagram), and the result is a decrease of resistance in the local circuit and an increase of the resistance in the field circuit. More current will, therefore, flow through the local circuit and less through the field circuit. The generating capacity of the dynamo is instantly reduced, and any tendency to produce a current above the standard is overcome. Should the tendency of the current be to decrease, say by a reduction of the speed of the armature, the slide lowers, increasing the resistance in the local, and reducing it in the field circuit. More current will then flow around the field magnets and less out on the local circuit. The generating capacity of the dynamo will, therefore, increase to maintain the current at standard. It should be stated that the use of resistances for balancing the field and local circuits is a small amount compared with that used by the lamps and is not interposed, as can be seen, for the purpose of compensating for lamps turned off.

The Waterhouse system, according to American exchanges, has been in use two years, has passed successfully the experimental age, and is now regarded as one of the excellent systems of electric lighting.

A DEFENCE OF THE BROWN EXPERIMENTS.*

By HAROLD P. BROWN.

AFTER my demonstration on July 30th, a gentleman, who I have since been informed was Dr. P. H. Vander Weyde, came forward and asked a great number of questions, which I answered carefully, giving him several diagrams of connections. From his paper, which was published in the *Electrical World* of September 8th, I see that he entirely failed to understand me, and has apparently not heard of the continuation of the experiments under the auspices of Dr. Cyrus Edson and Dr. C. F. Roberts, of the Board of Health, on August 3rd. As the official report of these experiments has not been published by any of the electrical papers, I here give it:—

At the School of Mines of Columbia College, this morning at eleven o'clock; experiments were undertaken at the request of Harold P. Brown, electrical engineer, to determine the danger of alternating currents, by Dr. Cyrus Edson and Dr. Charles F. Roberts, of the New York Board of Health. The first dog operated upon was a mongrel dog, weighing 61 pounds, strong and in good condition. His height was 24 inches, length, from tip of nose to base of tail, 42 inches, and resistance, from the right front leg to the left hind leg, 14,000 ohms. Connection was made by binding a piece of cotton waste saturated with water round the leg with No. 20 bare copper wire. The dog was placed in the cage and the alternating current applied by Dr. Roberts at 272·16 volts for five seconds; number of alternations, 288 per second. The dog was silent and motionless during the continuance of the current. He gave a few spasmodic gasps 31 seconds after current was first applied, and heart ceased beating 90 seconds after current was applied. The dog was immediately dissected by Dr. Roberts and Dr. Peterson, and section of sciatic and pneumogastric nerves, muscular fibres of diaphragm and lungs placed under a microscope, and no changes in structure were observed. The second dog was a full-blooded Newfoundland, strong and in good condition, weighed 91 pounds; length from tip of nose to base of tail, 48 inches; height, 25 inches; resistance, 8,000 ohms. Connection was made in the same manner as above. Alternating current applied by Dr. Roberts at 340·5 volts electromotive force for five seconds. The dog was silent and motionless during continuance of current; howled and gasped for eight seconds after circuit was opened, but in the opinion of physicians present this was purely mechanical action, as the dog was unconscious from the instant the current first reached him. Heart stopped beating in two minutes and fifty seconds after current was first applied. The third dog was a half-breed setter and Newfoundland, weighing 53 pounds, 42 inches long from tip of nose to base of tail, and 24 inches high. Resistance, 30,000 ohms. Connections were made in the same way as before. Dr. Roberts applied the alternating current at 220 volts for five seconds; the result was not fatal at four minutes afterwards. Mr. Porter, superintendent of machinery of Columbia College, then suggested that as the dog was rigid and motionless during the continuance of the shock, it would be impossible for a man in the same conditions to utter a sound or to break the contact in five seconds. Dr. Edson then determined to administer the current at same number of volts for 30 seconds on this account, and on account of the high resistance of this subject. This was done, and during the period of the 30 seconds the voltage rose to 234 volts. The dog died instantly without sound or struggle. The resistance after death was found to be 2,800 ohms. All of the physicians present expressed the opinion that a dog had a higher vitality than a man, and that, therefore, a current which killed a dog would be fatal to a man under the same conditions. It was their opinion that all of these deaths were painless, as the nerves were probably destroyed in less time than that required to transmit the impression to the brain of the subject.

Dr. Edson invited Elihu Thomson, of Boston, and Dr. Otto A. Moses to be present with measuring instruments to check up the voltage, &c., but neither of these gentlemen put in an appearance or responded. Approved by Dr. Cyrus Edson, of the Board of Health; Dr. Chas. F. Roberts, Assistant Professor of Physiology, Bellevue Hospital Medical College; Dr. Frederick Peterson, Dr. Frank H. Ingram, Dr. H. A. Haubold, Mr. John Murray Mitchell, Professors C. E. Colby and E. H. Laudy, of Columbia College; Capt. E. L. Zalinski, U.S.A., and Dr. Schuyler S. Wheeler, electrician of the Board of Electrical Control.

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* *Electrical World.*

Dr. V., whose article states that he is an anxious seeker after scientific truth will, of course, pardon me if I set him right on matters wherein he is very greatly mistaken. He must first appreciate that it has long been known that continuous currents of high tension would kill, so that it was not necessary for me to prove it. But I had stated that if a relay should be so arranged as to take the extra current, which he so graphically compares to "water-hammer" in pipes, the continuous current of 1,000 volts and more would do no damage. He admits that I succeeded in proving this, but takes me to task for doing so. The same experiment further proves that apparatus for shutting down the current the instant a ground connection is made even though it be made through a living being, would prevent fatal results. Such apparatus, therefore, would very much diminish the dangers of arc lighting.

But the alternating current employés had publicly declared that their current was "perfectly safe" and "absolutely harmless" at 1,000 to 1,200 volts, and it was therefore necessary that I should prove that the alternating current would instantly destroy life at less than one-fifth this pressure. This I attempted to do, but the interference of the S. P. C. A. left the matter unproved until the following Friday. Other experiments since made at the Edison laboratory by Mr. A. E. Kennelly, confirm my results, and only those who are financially interested in alternating current systems, or in "new and very peculiar" designs of converters can doubt such results.

Evidently Dr. Vander Weyde has never heard of the Cardew voltmeter, as he takes exception to its principle, and says that it must be an ammeter; will he tell me wherein voltmeters of the ordinary type differ from ammeters except in their resistance and calibration? If Dr. Vander Weyde will write to Professor Forbes or to any other prominent electrician who has time to keep posted on current inventions, he will find that what he calls a "pretended" voltmeter is in good and regular standing as a correct and reliable instrument, and that the "indications of rise in temperature" can be and are used for measurements of both current and E.M.F. See page 467 of the third edition of S. P. Thompson's "Dynamo-Electric Machinery." The voltmeter in question was loaned to me on July 30th by Mr. Thomas A. Edison, and Mr. A. E. Kennelly, his chief electrician, who calibrated it immediately before my use of it, will verify my measurements. In fact, Mr. Kennelly himself made all observations of the E.M.F. on the day in question, and he will also bear witness that Dr. Vander Weyde is *entirely wrong* in saying that the voltmeter and ammeter were in series. How the doctor made such a mistake I cannot imagine. The ammeter was in series with the subject when the continuous current was used, and the ordinary type of potential indicator was then connected in parallel, as shown in my diagrams. But when the alternating current was used the Cardew voltmeter was in parallel with the subject, and, as we could obtain no ammeter for this current, we measured the resistance of the subject and calculated the current.

Dr. Vander Weyde says: "I must also not omit here to state that if Mr. Brown had known the proper quarters where to apply for apparatus to determine properly the voltage and ampères of alternate currents, he could have been provided, and his labours in that direction might have had some value." I not only in a published letter asked that such apparatus should be brought, but in my invitations I particularly requested the leading representatives of the alternating current companies to bring such instruments. Before my experiments I asked them to appoint a committee of three to come forward and check up my measurements; no one responded but Mr. Smith, who brought nothing but a complaint that his invitation, which was one of the first I mailed four days previous, had not reached him sooner. I gave every one a fair chance to prove whether or not my measurements were correct, and it is therefore very unfair and unscientific for Dr. V. to question my results at this late date. Had I known him to be connected with the alternating current interests, I should have invited him to bring his instruments. I will here say to him that experiments with the same current are now in progress, and if he will agree to publish results in the same papers in which his article appeared, and will bring standardised instruments for measuring the current and E.M.F., and allow same to be afterwards calibrated by the authorities in charge, I will see that he is invited to participate.

What the Doctor says concerning the fact that "Voltage alone is no criterion in regard to the danger of a current" is correct, but he must not forget that with a constant potential, the resistance of a living subject is rapidly reduced and the current correspondingly increased. For example, the resistance of the third dog killed by the alternating current on August 3rd was at first 30,000 ohms; after death it had fallen to 2,800 ohms; the voltage that killed it was 234. From this Dr. V. may calculate the current for himself, and as Dr. Schuyler S. Wheeler made the measurements in this case, he must not talk of the "worthlessness" of the observations. But to return to his article, may I ask him to explain how he came to make such an assertion as this: "According to the statement of the engineer, the engine driving the 125 ampère dynamo requires 36 H.P., that of the alternate dynamo 36 H.P.; together, 72 H.P., which at 746 watts per H.P. gives 54,712 watts?" There was a time when Dr. V.'s method of estimating power required by a dynamo was correct, and that was when any translating devices that were not in use were replaced by equivalent dead resistance, so that the electrical output of the dynamo was the same, irrespective of the current utilised. But this state of the science is long since past, and power required to drive the modern dynamo varies in almost direct proportion with the load.

In the case criticised, the load in the final experiment with the continuous current was simply the power required to maintain 1,000 volts through 2,100 ohms, the resistance of the dog at that time, in parallel with the resistance of the pressure indicator and the resistance of the field magnets. This would be less than one horse-power appearing in electrical energy, of which about 476 watts passed through the dog. But when the alternating current was used a third of this amount proved fatal.

"After all," says Dr. Vander Weyde, "we must not lose sight of the main object of this controversy, which is the comparative danger lurking in the two systems. When it is found by experience that actually the danger of being killed is greater by the use of alternate currents, it does not make any difference if the voltage which does the killing is 300 or 1,300." If it is meant by this that if 300 will kill we might just as well use 1,300, the doctor is mistaken, since the higher the pressure the greater will be the leakage to ground through the insulation, and at 1,000 to 1,300 volts this leakage will be sufficient to kill a person standing on a damp place and touching either one of the primary wires; whereas at 300 volts the leakage would be scarcely dangerous, though a person might be killed by touching *both* wires. I am at present making experiments which tend to show that arc light dynamos may be operated up to at least 2,000 volts without any danger, and shall in due time publish results. But until my previous results, printed in the *Electrical World* of August 11th, have been disproved by practical experiments, it must not be forgotten that I have proved that 1,420 volts continuous current may be made harmless, while 170 volts alternating applied to an exactly similar subject kills. If, in spite of this, the arc lighting companies prefer to put themselves by resolution upon a par with the alternating current in regard to danger, so much the worse for them.

Mr. Gutmann also criticises me, and says that the best place for the converter is indoors; true, it is the best place for the converter itself, but the best thing for the safety of the persons in the house is to keep the primary current out. The danger is not so much to a person touching the secondary as it is to a person touching either primary wire when on a damp place; and the placing of a grounded piece of copper foil around the primary coil in the converter of course diminishes the insulation and increases the leakage. Several cases to prove this will, I believe, soon be published. Mr. Gutmann seems to be a fair-minded man, and says that I ought to ask permission to experiment with the apparatus of a regularly equipped alternating current station, and wants to have certain experiments that he suggests tried. If he will give permission to use current from his station in this city, such experiments will be made at once by competent authorities, and I hereby ask such permission.

I understand that an official list of the persons killed and crippled by electric lighting is being made; in its present incomplete state it shows that the number of victims of the alternating current in this country is already far in excess of its proper proportion when compared with arc lighting, and this result is obtained from new plants with presumably good insulation. It is by no means "an idle occupation," as Dr. Vander Weyde says, to bring these facts before the public, as human life is too valuable to be trifled with. Governor Cornell's letter, proposing to prohibit high tension currents by law, is exactly what I predicted in my article in the *Post*, and it is the outcome of the persistent neglect of the electric lighting companies to take all possible means to secure public safety.

Each additional homicide caused by poor insulation, inadequate testing for grounds or too high pressure, will be an argument in favour of legislative prohibition instead of wise legislative regulation, which not even an alternating current "trust" of 20 millions can overcome.

DYNAMO CURRENT INTERFERENCES WITH TELEPHONE SYSTEMS AND MEANS OF RELIEF.*

By C. E. McCLUER.

DURING my earlier telegraphic experience I became imbued with the universally accepted belief in the theory that the earth was an immense reservoir of electricity, and that on that account, and because of its immense mass, it offered no appreciable resistance to the transmission of electrical force. Hence the universal use of the earth as a return conductor for telegraph and other electrical circuits, which are, in consequence called "mixed circuits," in contradistinction to circuits composed wholly of metallic conductors. But my attention being called to the behaviour of our telegraphic apparatus under the influence of extraneous currents,

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* Read before the National Telephone Convention of America.

I was finally led to question the correctness of the theory of the "infinite conductivity" of the earth.

Like nearly all of the early workers in the new field opened up by Prof. A. Graham Bell's invention, I was also led into the error of attributing to "induction" nearly all the ills to which the telephone was heir.

Experience and observation, however, soon convinced me that nearly all the telephone troubles popularly supposed to arise from "induction" were the result of "leakage" only; "induction" operating only at minute distances, while leakage would occur across wide intervals. Hence I was to some extent prepared for my subsequent experiences with the effects of electric light and electric power circuits upon telephone systems, experiences which, as I will now proceed to explain, confirmed me in my disbelief in the theory of "infinite conductivity" and the effects of "dynamic induction."

Some three or four years ago Richmond was captured by the advance guard of the army of knights of the dynamo, to which she is now so largely tributary, and the Schuyler Electric Light Company soon had the city ablaze with arc lights. At first we experienced little or no trouble, but after a time strange noises were heard in our Exchange telephones, and as the electric light construction was extended and circuits and arc lights were multiplied, the noises increased until they finally became a din over which it was almost impossible to project the voice. After careful consideration I suggested certain reversals of dynamo currents and re-arrangement of the electric light metallic circuits, which were adopted by our electric light friends, greatly to our relief. But on some of our Exchange wires, notably those on our Broad Street trunk line extending to the extreme western and north western limits of the city, the howling of the dynamo currents remained comparatively unabated.

After further consideration I became convinced that the principal source of our telephone troubles was a long electric light circuit which traversed Main Street to the western limits of the city, then crossed northward to Broad Street, which it followed eastwardly to a point opposite the power house, and thence in a southerly direction to the dynamos, thus making a loop about a mile and a-half in length by a quarter-mile in width. One side of this loop ran parallel with our Broad Street trunk line, almost the entire length, with only the width of the street between them. I was at first inclined to attribute to the usual scapegoat, "induction," the interference which we experienced on our Broad Street wires, but my attention being about this time directed by some of my linemen to the interesting fact which they had discovered, that even in the dryest weather enough of the dynamo current on this large loop escaped over the insulators and down the poles to be perceptible to the tongue when applied to a pole four or five feet from the ground, while in rainy weather a very perceptible shock could be felt by applying the hand to a wet pole.

My former opinions regarding "induction," *vs.* "leakage," and the "infinite conductivity" of the earth were recalled to me with redoubled force, and I soon settled down to the conviction that *leakage* was the force with which I had to deal. This conviction was strengthened by the well observed fact that the interferences from the electric light currents were greatly increased during wet weather.

But the famous Richmond Union Passenger Railway with its street cars propelled by electricity became a moving, flashing reality in January of the present year, and for a time rendered the telephone business in Richmond decidedly interesting. Unlike the electric light and power systems, the electrical plant of the railway company was not designed or arranged for metallic circuits, but was and still is operated by mixed earth and metallic circuits, the currents being carried to the overhead trolley wires by a system of distributed mains, supported upon poles on one side of the street, these mains being connected at frequent intervals with the trolley wire by short lateral wires termed "feeders." As operated in Richmond, the electric railway system requires a double line of poles, one line on each side of the street, for the purpose of carrying non-electric wires which extend across the street, between each pair of poles. These are termed "supporting" wires, and are designed solely to support the trolley wires at the proper height above the middle of each roadway. These supporting wires and the network of special supporting or curve wires whose office it is to cause the trolley wires to curve parallel with the curves in the road bed, are supposed to be insulated from the trolley and feed wires and mains, but as we found to our cost, they were not by any means devoid of electrical currents. During the first six weeks after the inauguration of the electric road we had eight sets of telephones and one central office annunciator drop burned out by the railway currents, and about half of these accidents were due to crosses between our telephone wires and the supposed to be harmless supporting wires. While these accidents demoralised our linemen and operators to some extent, they fortunately resulted in but little damage to property and none whatever to human life, and but few of our subscribers learning of them they created no special commotion.

But the effect of the railway system upon our central office apparatus and telephones from the very inauguration of the railway plant to the present time, has been annoying in the extreme, and exceedingly detrimental to our exchange service. Almost the first revolution of the battery of railway dynamos tripped the annunciators of our magnetic lines and rendered necessary an immediate resort to the use of special armature springs to overcome the magnetism imported by the currents from the railway wires. Our "testing off" galvanometers were inoperative, because at first the polarity of the extraneous currents was opposed to that from our galvanometer batteries, and the galvanometer needles were deflected in a direction contrary to the position assumed when under the influence of the batteries alone, the leakage from the railway wires being sufficiently strong to overcome the current from three cells of Law or Leclanché battery.

This trouble I remedied by reversing the poles of my galvanometer batteries so that they would, with the exception to be mentioned, coincide in polarity with the extraneous railway currents. This exception, coupled with the continuous and steady nature of the extraneous currents confirmed me in my belief that it was leakage and not induction from which we were suffering.

At the power house or dynamo rooms of the railway company, distant three or four squares from our central office the battery of five or six dynamos which furnished the current for the car propulsion was grounded, the negative electrodes being connected to several large sheets of copper at the bottom of a deep well upon the premises. The positive electrodes of the dynamos (coupled up of course in multiple arc) were connected "to air," as a telegrapher would put it, or to the distributing mains. From all our exchange stations located in the vicinity of the dynamo rooms, within the radius of an entire block, in fact, we would therefore get a negative leakage current, while from all other stations which we grounded within a square of the railway track and wires, we would obtain a positive current, thus rendering it impossible to arrange our galvanometer batteries to coincide with these leakage currents of opposite polarity.

We cannot, therefore, to-day use our galvanometers for testing off the few stations located in the immediate vicinity of the dynamo rooms. Identically the same effect was produced upon our head-phone test circuits, the railway currents completely neutralising the currents from our "test" batteries.

This difficulty was also removed by reversing the poles of the batteries.

The exchange lines most greatly affected by the railway currents we soon found by experience were those which were grounded nearest to the railway tracks, irrespective of the general direction of the wires or their proximity to or distance from the railway. Lines that in no place approached within less than a square of the railway wires being as greatly affected as many others that ran parallel with and in close proximity to the railway wires for long distances, but which terminated and were consequently grounded at points comparatively remote from the railway.

In like manner lines grounded near the heavier grades and curves of the railway, where the motor men are compelled to use the maximum amount of power in order to ascend the grades or round the curves with heavily loaded cars, are more seriously affected than lines grounded near the levels.

So clearly is this the case that our operators can readily tell, from the character of the disturbance which they experience, when a car is ascending a grade, or when it stops or starts.

This effect of the movement of the cars you, of course, understand is due to the fact that the dynamo currents, when propelling the cars, are short circuited from the trolley wires through the motor fields and armatures to the earth, thence spreading over every available conductor in their efforts to reach the dynamos. But the maximum disturbance is experienced when three or four cars are following each other in close file, either on a grade or level. In that case the leakage due to each car traverses the contiguous telephone wires simultaneously, producing in our telephones a composite or mixed tone, each motor having its distinctive timbre or tone quality, and all united fairly making Rome—or the telephone, rather—howl, and drowning out the puny currents induced by our microphone batteries.

Learning that the railway people were utilising the municipal gas and water mains in order to reinforce their ground connections, it occurred to me that possibly the fact of our lines being generally grounded on the gas and water pipes had much to do with our troubles. I had some of our old wires removed from these systems and connected direct to the earth through made grounds, but without altering the results.

The 450 or 500 volt currents of the railway mixed circuit system do not, however, interfere as greatly with our Richmond Exchange service as the 4,000 or 5,000 volt currents carried by the metallic circuits of the electric lighting systems. Did the railway service require currents of the same E.M.F. as the arc lights, the telephone would have to retire from the field—lose ground, in fact, as metallic circuits would be their only salvation. What the railway currents lack in E.M.F., however, they make up in current strength, and are, therefore, more dangerous to property than the much more intense electric light currents. The latter will melt a fuse or burn out an arrester instantaneously, before time is given it to enter a central office or a subscriber's station and damage the telephone or outfit; while the less rapid but larger quantity of the railway current takes an appreciable time to melt or fuse an arrester, thus permitting it to burn out a hand-phone, an induction coil, or a bell, or annunciator magnet, before the protector, of whatever kind it may be, can properly act.

In *my* experience the greater tension of the electric light currents renders them doubly disastrous to telephonic exchange service, the voice being more completely drowned by the intense disturbance due to the electric light escapage than it is by the escaping currents from the lower tension dynamos. But the fact of the electric light being in demand, particularly the arc lights, only after business hours, renders the disturbance engendered by them less noticed by subscribers generally than the weaker and less marked disturbances proceeding from the railway generators which are continuous throughout the entire business hours of the day, when the telephone service is in constant demand. Did the arc light service continue during the hours of daylight, as at night, telephone exchanges would be compelled to suspend operations or adopt the only alternative, metallic circuits, with the attendant increase in complication and expense.

Having thus discussed the effects of extraneous electric light and railway currents, let us address ourselves to a brief consideration of the remedies which we have at hand. Anti-induction devices for the elimination or exclusion of extraneous currents from telephone circuits, whether they be artificial or natural, are plentiful, but none have yet been devised that can at all compete with the old-style metallic circuit.

But the metallic telephone exchange system carries with it not only a double expense for construction, maintenance, and repairs, but a vast outlay and increased complication and expense for central office plant and service, there being two line wire terminals to provide for every subscriber, and necessarily four terminals to handle for every connection, instead of two, as with the single wire and earth systems.

This great increase in wires, in complication and consequent liability to derangement, and in initial cost, and subsequent expenses for operation and maintenance, almost prohibits the adoption of the ordinary metallic system. None but the wealthy, like our long distance friends, can afford such a luxury. But there *is* a metallic circuit system within reach of even the poorest of the American Bell Co.'s lessees, a system of my own devising, and which I have found by practical tests to accomplish all that can be derived from an ordinary metallic circuit, and at but a tithe of the expense.

Recurring now to my theory that it was not "induction," but leakage that annoyed us, and the expression of my disbelief in the infinite conductivity of the earth, it will readily be seen how, after arriving at those conclusions, I would very naturally reason thus:—If our telephone troubles are due to leakage from the electric light and railways, and this leakage overflows into our wires from the earth *because* the earth offers an appreciable resistance to their passage, why cannot we adopt a metallic conductor of exceedingly low resistance, or of a conductivity approximating that of the earth, and use *it* in place of the earth as our return conductor, making it, in fact, what may be called an "artificial" earth or ground, and at the same time cutting loose from the earth entirely and gaining all the benefits of metallic circuits?

This idea I conceive to be in strict conformity with Ohm's law, and if only the relative resistance of the "artificial ground" or earth and the line wires attached to it were properly adjusted, we would have identically the same results achieved by the usual earth connections, and without the disadvantage of the mixed circuits. This thought revolved in my mind for some months before I could find time and opportunity to verify its truth or falsity by experiment. Besides, the device was so simple that I could scarcely conceive that it was possible that it had not already been tried and found to be impracticable by some member of the army of electricians that had been so long engaged in efforts to solve the anti-induction problem, and it was only after conferring with some of my brother telephonists, who were favourably impressed with the idea, which was novel to them, that I took the time necessary for experiment. I, however, finally connected up several telephone circuits with a common return wire of low resistance, and found that conversations could be carried on, and a magneto call bell rung on each circuit without any mutual interference whatever, and it required a resistance of 35 ohms by galvanometer measurement to be added to the common return wire before the currents propagated in one circuit could be heard in the telephones on the other circuits. I thus concluded that there was approximately 350 ohms resistance in each circuit, due to the conducting wire, the call-bell magnets and the hand-phones and transmitters, that the "artificial ground" wire should bear to the other side of each circuit, the direct or line wire, a resistance approximating one-tenth that of the entire circuit.

Encouraged by this experiment and anxious to do something to improve the night service of my Exchange, I laid my scheme before the executive officers of my company, and was furnished with a half mile of No. 4 copper wire with which to make some practical tests.

My first experiment was with our No. 19 northern call-wire and its connecting lines. This was our shortest call-wire, being only a third of a mile in length, and had connected with it some 18 or 20 subscriber's stations, located in close proximity to the Seventh Street grade of the electric railway, an 8 or 10 per cent. grade, extending from Franklin to Grace Streets, one square.

At the corner of Seventh and Franklin Streets the main feed wires of the railway plant direct from the power house two squares distance, first touched the line of the railway and divided right and left to the opposite and distant ends of the road. At this point, as might have been anticipated, and on our telephone lines grounded in this vicinity, we experienced the greatest interference, particularly when a heavily loaded car was ascending the hill. My "artificial ground" gave us immediate and remarkable relief from the railway leakage, and without any cross talk whatever.

I then applied for a half mile of No. 6 covered copper wire, which I connected to the end of the first half mile of No. 4 wire, and extended my artificial ground wire on out to the western end of the city, intending to make my next test with one of our longest taps and our longest lines, with stations located near the most westerly extension of the long Main and Broad Street electric light loop of which I have already spoken. These lines had been almost entirely abandoned at night, our subscribers averring that they could not use their telephones at all after the electric lights were ablaze.

The worst of all was a station in a drug store, whose proprietor had long made bitter complaint that his telephones were of no service to him whatever after dark. Yet when the change was made from the natural to the artificial ground at this and all other stations on that call wire tap, the relief from the electric light leakage was as instantaneous and marked as that experienced from the railway leakage on short tap No. 19. In fact, such was the change wrought on these wires that it was possible to carry on a whispered conversation over lines connected to my artificial ground, that when connected to the natural earth were so noisy that even the loudest shouting could be heard only with extreme difficulty.

While cogitating over my idea in its incipiency, it occurred to me that even the adoption of a *general ground wire* of high conductivity would relieve our telephone wires from the influence of these extraneous currents, to a great extent. This I found from experience to be true.

When arranging for the central office end of my "artificial ground," I had made a plug switch so arranged, that by the insertion or removal of a single plug I could connect the artificial ground wire to earth, or disconnect it entirely from the earth, and with one motion connect it with all of its attached wires, into a "compound metallic circuit system."

I could thus readily note the difference made by the use of the large copper wire as a *general ground wire*, or as a substitute for the earth. In the one case, as you understand, if I have made the matter clear to you, the large copper wire was connected to earth at only one point through the plug switch in the central office, while in the other it was disconnected from the earth entirely.

Mr. McCluer: For fear I have not made this perfectly plain I will interpolate here in a little stronger language if possible the difference between these two arrangements. In the one case, using this large common return wire of large conductivity as a general ground wire, you will understand that all the stations on the route followed by this large common return wire were disconnected from the earth entirely, and the ground pole connected to this artificial earth instead, none of the subscribers lines or stations being connected to earth at all, but all of them on the current generated by the microphone batteries seeking ground from this general ground, by the ground in the general office. But by means of this plug I have arranged, I could at any time I chose to make such an experiment—by withdrawing this one plug I could detach this general wire from the earth entirely so that I had a system of purely metallic surface—no earth connection whatever.

Mr. Durant: Allow me to interrupt you one moment. You say you disconnect by means of a plug from the earth. Now what was it that connected it at the central office?

Mr. McCluer: I had one of the operator's head-phones connected to that instead of the earth, and I also had one of the operator's sets of telephones in the central office connected to that in the same way; so that by putting the taps that had been changed from the natural to the artificial ground all on that one head-phone I could place all those stations on one operator, or I could put it on my own ear so that I could receive all the orders given by subscribers over the metallic surface. There is no ground connection at all; the central office operator's head-phone and this operator's telephone and transmitter being connected to the other end of the artificial ground, and, of course, connected inside, we may say, of the point at which the ground wire was connected on; there being two plates, one heavy brass plate to which this artificial ground and the telephones were connected, the other plate having nothing attached to it whatever but the wire leading to the natural earth.

Mr. Lockwood: Then, Mr. McCluer, the subscribers' lines were connected at the subscribers' stations. Instead of each of them being connected to its individual ground wire, a group were connected to one large return wire. Then, was the central office end of the large return wire connected to the central office ends of the individual wires when you took your plugs out?

Mr. McCluer: No, sir; it is left open. You understand that we, the Southern Bell Telephone and Telegraph Company, are exploiting the Law system; we do not use the magneto, and, of course, we have no grounds on our wires in the normal condition at all. It is only when the line is connected to another line that there is a ground at each of the subscribers' stations, but none at the central office whatever.

Mr. Gifford: That would not work in the magneto system?

Mr. McCluer: It would work in the magneto system if you took the subscribers' lines and connected them to this artificial ground. It is just as though you were taking a strip of earth extending the whole length of your route and digging that up and lifting it on your poles. In other words, you look upon this wire in exactly the same light as you look upon the ground.

To those familiar with the details of a telephone exchange it will be clear that some such provision for grounding or connecting artificial grounds to Mother Earth is essential, as long as any of the wires of the system remain in connection therewith, because yet changed to the artificial ground to those that have been thus changed, otherwise the one will be of the necessity of connecting stations not grounded, and the other "dead open," and consequently inoperative.

In this way I found by experiment that when the large copper conductor was to earth at the central office, and being used simply as a general ground wire, the electric light and street railway interferences were reduced about 50 per cent., and when used wholly detached from, and wholly in place of the earth, they were reduced the other 50 per cent., or eliminated entirely.

So I take this No. 19 tap, connect that into an artificial circuit by itself. I might put that on a single head phone and let one operator wear that. She would get all the orders over the call wire with perfect distinctness and without any trouble whatever, but when she went to connect a subscriber on that call wire to another subscriber in another quarter of the city whose station was still connected to mother earth, of course we would have the case I mentioned here. The station of the subscriber that had not been changed to the artificial earth would be grounded, the other station would be dead open, and, of course, there would be no chance of any conversation except through the leakage that occurred in the pole. When my experiments were in progress I would receive an order from a subscriber on this metallic surface; I would repeat it to one of the operators, and the two subscribers would be carrying on a conversation; but the first thing said would be, "What is the matter? You sound as if you are 1,000 miles away." They would get distinct articulation, but in a much weaker tone.

You understand that when this general return wire was used as a general wire, all of the wires on such a tap being connected to this one ground wire, and all seeking earth at the central office instead of at the point where the subscribers' station was located, it reduced the interference from street railway and electric light currents at least 50 per cent., so that where it was only with difficulty that you could make a man understand what you said, with this general return wire we can hear very well indeed.

Mr. Gifford: That general ground wire was grounded in the central office?

Mr. McCluer: Grounded in the central office. But when made wholly detached from and wholly in place of the earth, they reduced the other 50 per cent., or eliminated it entirely. On these stations I spoke of before the leakage from the electric light wires have been so strong that the subscriber could not use his telephone at night, and the operator could not hear him with distinctness when he ordered a connection. Therefore he told me he never thought of using his telephone after the electric light had been started. As soon as I had this tap connected to one of these artificial ground connections, I sent one of my inspectors to make some experiments. He called me over this general ground wire. The operator heard his order to connect with 180, which is the chief operator's telephone in the central office. I went to the telephone and talked with him without any difficulty at all. Then I removed this plug from the switch and converted that ground wire with all its attached wires into a metallic circuit, and he and I then carried on a conversation in a whisper, of course getting close to the transmitters, as you have to do under those circumstances. But I just mention that to show you the difference between the general ground wire and the metallic surface. Then, when I made him take out the general ground wire and replace the old natural wire, the din from the electric light was so great that he could not hear a word. I then called the subscriber to the telephone, and the very moment I spoke to him he said, "Hello, what have you done here?" I told him I had been experimenting to see if I could not relieve him of the trouble he had been complaining of. He says, "You have done it." I then took the plug out of the central office, disconnected the earth entirely, and talked to him over the metallic circuit. He then expressed still greater wonder that the electric light was gone entirely, he could not hear a sound of it. I then made some remark in a whisper which he heard without difficulty, and replied to me in the same way.

Now, of course, in practice, it is much more convenient to have this general ground wire, as I ought to call it now, grounded at the central office. It is more convenient to do it for the purpose of manipulation, but the same effect would be produced if this general ground wire was carried to any other point in the exchange and grounded at a point remote from the railway or electric light plant.

By thus utilising the large conductor, *first*, as a general ground wire to carry the microphone, and signalling currents to the earth at the central office, or at any other locality remote from the offending electric light or railway plant, an exchange system can be gradually converted from a mixed metal and earth system into a compound metallic circuit system throughout, without any interference whatever with the service of the exchange, and to its manifest improvement during the time the change is being made. And when the last subscribers' line has been transferred from the natural to the artificial earth at the last station, it is only necessary to withdraw the solitary plug that still connects the system to the earth and, presto! you have an exchange of purely and practically metallic circuits alone, with all of the advantages, and without any of the disadvantages of the ordinary metallic circuit.

The one series of large copper wires extending out on the various trunk lines, but all united in one at the central office, answering fully the purposes gained by the ordinary duplication of each individual wire, and necessitating no change whatever in either central office or station outfits or appliances, beyond the single substitution of the artificial for the natural ground.

In practice it may be found that a greater proportion than one-tenth the resistance of any one circuit may safely be given to the artificial ground wire, but my experience and experiments lead me to believe that it will be far safer and more satisfactory to keep the resistance of the artificial ground to one-twentieth that of the entire circuit.

In an exchange the size of our Richmond Exchange, I advocate the use for each individual trunk route of a similar copper conductor composed of a half-mile each of No. 4 and No. 6 wire, with No. 8 for lateral lines and the remaining distance to the farthest stations, with No. 14 to stretch from the poles into the stations. All of these wires should be of hard drawn copper with a good covering, and strung on the same poles and fixtures that carry the regular exchange wires, but insulated carefully both from them and the earth. And I should place those artificial ground wires at the lowest point on the poles, or the least distance from the sidewalk or ground, beneath all of the line wires if possible.

In this position the small amount of leakage currents that are attracted up the poles from the earth, whether from electric light, electric railway and power circuits, or earth currents, will be intercepted by the large copper wires, and by them carried to those points in the system where they will escape to earth again without any adverse influence upon telephone wires proper.

While in the absence of any direct experiments, I cannot say positively that such will be the case; I however believe that if our long-distance friends will couple together so as to make of some eight or ten of their No. 12 or 14 copper wires practically a single low resistance conductor, they will find that this compound conductor will answer as an artificial earth or return wire for treble or quadruple the number of wires thus coupled together, while a single conductor of the same conductivity would double the capacity of their poles, and the number of their metallic circuits.

In like manner, I believe the same principle can be applied to telegraph and electric light or power circuits, relieving them from the disturbing and damaging influences of earth currents and atmospheric electricity, and conferring upon them all the advantages of metallic circuits without the ordinary duplication of wires.

In conclusion allow me to say, that while I flatter myself that I am charitably disposed, and ever inclined to do all that within me lies to further the interests of the telephonic fraternity, and increase the efficiency and value of our telephone service, I do not think I am justified in assuming the role of public benefactor and giving my device away, even in the interests of science. Believing it to be novel, practical and valuable, I have therefore conceived it to be my duty, as well as privilege, to apply for a patent, and my application is now pending, with, I trust, a good chance for a favourable decision.

Mr. Lockwood: Mr. McCleur is quite right in attributing a certain amount, at least, of the disturbance, and perhaps nearly all the disturbances occurring from electric railways to absolute leakage of electricity from the rails to the telephone wires; but like nearly every person who has at one time adopted one theory for certain phenomenon, and at another time another theory, I think he has become an extremist, and as is usual, the mean is the correct view. A great deal of our disturbance on telephone lines is still due to the old enemy—induction, and although the telephone business is eleven years old now, induction is still just as strong as it ever was. The trouble that electric lighting, and especially arc lighting, has given to telephone men is of two-fold character; first, of the character which disturbs the conversation; and secondly, of the character which destroys the wires and apparatus. Within the last year or two we have become apprised of another enemy in the lighting camp, namely, the alternating current used for incandescent lighting, and these are used not only through converters, but also on direct dircuits.

THE BRITISH ASSOCIATION.

ELECTRICITY AS APPLIED TO MINING.

By FRANK BRAIN, M.E.

(*Section G.—Mechanical Science.*)

Monday, September 10*th.*

THIS is a paper from the mining engineers' standpoint, briefly sketching the known applications of electricity to mine working up to the present time.

The writer regrets there is little to add to what has already been made public. He cannot but express surprise that a power which it is apparent has now passed the range of experiment and is developing itself economically and efficiently, should not have been made greater use of than appears to have been the case hitherto.

The recommendations of the Mines Commission, and the passing of the more stringent Coal Mines Act of 1887, both have stimulated mine managers to enquire into and recognise the advantages of electricity for blasting and lighting.

By means of a small hand magneto battery and electric fuses all the shot firing in most of the fiery collieries is now done, the explosive used being one of the many lately introduced, which fired by an electric detonator gives off no flame. Dynamo machines at many pits are used for lighting the surface and main roadways of the colliery, and this current has also been used for the purpose of shot firing, notably, at Ynyshire Colliery, Rhondda Valley, South Wales. All the shots are fired in this way simultaneously, with every man out of the pit, thus putting loss of life beyond possibility.

This adaptation, it should be said, however, is protected by a patent. The adoption of the electric lamp in place of the well-known safety lamp is now very strongly advocated; there are several in the field, notably, the Swan and Pitkin, secondary batteries, and the Schanschieff, a primary battery.

The South Wales Institute of Engineers (who have referred the matter to a special committee), with other kindred societies, have lately had these and other lamps put before them, and several colliery engineers are practically testing them.

One, Mr. G. W. Wilkinson, of Risca, has in use daily several hundreds, and so satisfied is he with their results, he has ordered a further number for other of his collieries.

The lighting of the main roadways by electricity is common in many mines. Mr. Sopwith, of the Cannock Chase Collieries, who, it will be remembered, read a paper in connection with the 1886 meeting of the British Association on the subject, informs me his plant, which has since been extended, continues working well. He has lately introduced large accumulator cells to supply 12-volt lamps in various parts of the colliery workings, where moisture and a very bad roof had to be contended with. He found there was no difficulty with the leads, and the result was in every way satisfactory. The applications of electricity to transmission of power are confined to a few collieries. So far as the writer knows, in Great Britain to three only, viz., Trafalgar Colliery, Forest of Dean, St. John's Colliery, Normanton, and Allerton Main Colliery, Leeds.

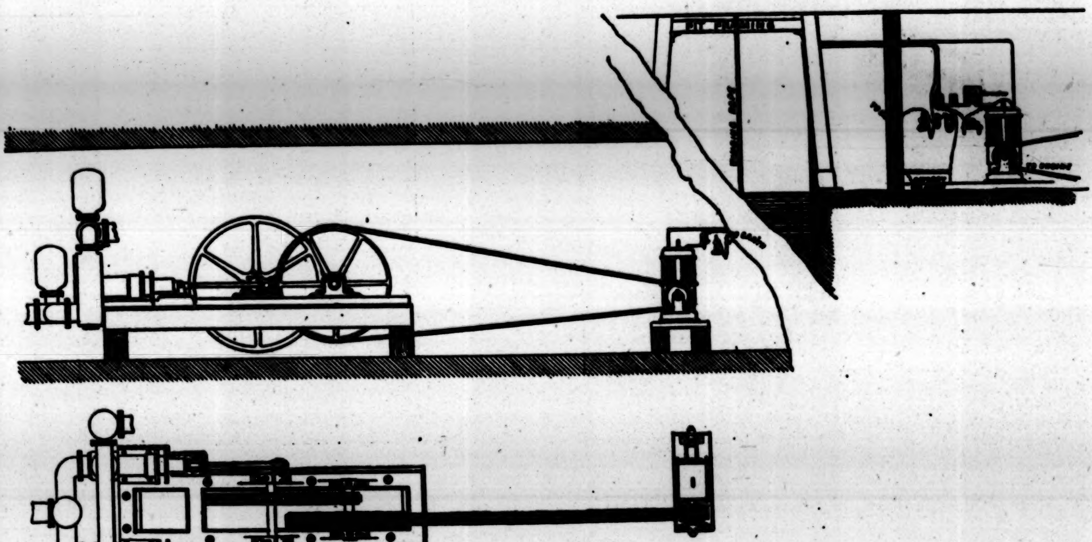

FIG. 1.

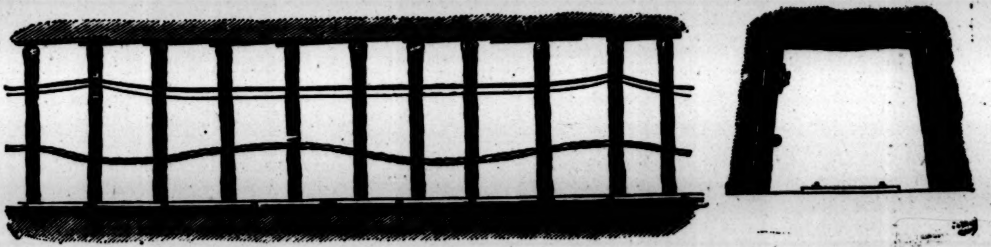

FIG. 2.

At Trafalgar, what was a very small pumping plant, started in December, 1882, developed in May, 1887, into three sets of plant, doing the greater part of the underground pumping of the colliery.

As the writer has been directly concerned in the working of this plant, a brief description of the last installation may be interesting.

The pump, a double-throw 9 inch plunger with 10 inch stroke, is fixed 2,200 yards from the generator and 1,650 yards from the bottom of the pit shaft. The pipe main is 7 inches and at a maximum speed of 25 strokes the pump lifts 120 gallons per minute 300 feet high. It is geared 6 to 1, the small pinion being driven by a belt from the motor (an Elwell-Parker). Current is conveyed to the motor by a conductor of nineteen No. 16 wires, insulated and carried on earthenware insulators. An old 4 inch iron wire rope serves for the return current. The current is 43 ampères, and the E.M.F. 320.

The cost of engine and electric plant was £644. The weekly cost of maintenance, allowing 15 per cent for interest and depreciation on plant, £7 17s., or ·002 of a penny per horse-power per hour, and the economy effected about £500 per annum. The power lost and useful effect in the different stages is as follows:—

Received by		Loss in		Useful effects.
Generator ...	23·00	Steam engine,	22 per cent.	78 per cent.
Cables ...	18·44	Generator ...	20 "	80 "
Motor	14·99	Cables ...	20 "	80 "
Pump	11·99	Motor ...	20 "	80 "
Water	10·36	Pump ...	14 "	86 "

The efficiency obtained throughout is only 35 per cent., but it will be noticed that the engine, which is an old one, loses 6·49 horse-power, or 22 per cent. alone. This plant has worked daily since May, 1887, without interruption, and is giving every satisfaction.

Figs. 1 and 2 are views of the pump, showing its connection with the motor, and of the leads along the underground roads.

Fig. 3 is a diagram divided into 22,000 watts (29·49, the indicated H.P. of engine), showing the percentage of loss at each stage, commencing with the engine, and also the effective work (35 per cent.).

Fig. 4 is prepared in a similar way, but takes the H.P. delivered to generator (23·0) as its starting point, thus showing the proportion of power given off by steam engine belt used to lift water to be 45 per cent.

Fig. 5 shows the useful effect obtained at the various stages.

At St. John's Colliery, Normanton, 39 gallons per minutes are raised 530 feet, equal to 6·3 horse-power work done. This is with an old girder engine which indicates 14·2 horse-power. The efficiency, therefore, is 44·4 per cent.

This plant commenced working in the latter part of 1887. In the early part of this year (1888), so satisfied were the owners of the colliery with its working, they laid down what is at present the largest electrical pumping plant in England. 120 gallons per minute are raised 900 feet, equal to 33 horse-power, nearly. The engine has not been indicated, which is to be regretted, but there is an output of 53 horse-power from the generator, so that the efficiency comparing the actual work done with the output of the dynamo is about 62 per cent. The current averages 66 ampères with an electromotive force of 600 volts.

Immisch motors are used here. These extensions speak for themselves. At Allerton Main Colliery very small quantities of water are being dealt with at inaccessible points, the power being taken to the motors in secondary batteries charged at the surface and conveyed in the colliery tubs.

Mr. Blackburn, the manager of these collieries, has also in work a coal-cutting machine. The motor is carried upon the bedplate of the machine, a rotary motion being transmitted to the shaft carrying the cutter bar through gearing. The current is conveyed to the coal face from the dynamo machine, placed on surface, by flexible cable.

FIG. 3.

On the Continent we have underground haulage at Zankerode Colliery in Saxony, which has been successfully and economically working since 1882. The distance from the dynamo—a Siemens and Halske—to the working level is 300 yards and the total length of the line is 700 yards. The current is carried by well insulated conductors to angle irons which run along the roof of the roadway, and from which the current is taken to the motor carried upon the locomotive.

FIG. 4.

A full train is 15 tubs, each containing 10 cwt., and the locomotive weighs 30 cwt. The speed varies from 5 to 7 miles per hour. The total cost of plant was about £800, and the cost of working about ¾d per ton. At Paulus and Hohenzollern Colliery in Upper Silesia a similar plant has been working since 1884. The distance from the dynamo to the working level is 250 yards, and the length of the line 820 yards.

The current is conveyed as at Zankerode. The full train is 16 tubs, each containing 10 cwt., and the locomotive weighs 42 cwt.

The cost is about ½d. per ton, or one-half cheaper than horse transport. A similar arrangement is also working in the Salt Mines of New Stassfurt, and at the Salzberg works. At New Stassfurt tail rope haulage has been applied.

In Australia the writer can only trace one application, and that is at the Phœnix Gold Mines, Skipper's Creek, New Zealand. Here two Brush dynamos driven by two Pelton waterwheels generate about 52 horse-power. A No. 8 B.W.G. copper wire on telegraph poles conveys the current over a mountain 800 feet high a distance of some 3 miles to a Victoria motor which drives 20 stamp heads (each of 8 cwt.) at the rate of 70 blows per minute, and it is said to be powerful enough to drive 30 heads. The loss in transmission is stated to be about 3 horse-power only.

FIG. 5.

In America the use of electric motors is much more extended than with us. The electric light companies hire them out for varied purposes, their large central lighting stations enabling them to do this to great advantage. Horses on street tramways are being fast replaced by the electric locomotive. For example—in one city alone, Richmond, Va.—with grades of 3 to 10 per cent., 200 cars driven by Sprague motors on the overhead conductor system are running daily, carrying some 80,000 passengers per week. It is stated the economy, as compared with horses, is 25 per cent. on gross receipts. It is but lately attention has been turned to mine work; but now they have commenced, with the push and spirit of enterprise which is a distinguishing feature with American engineers, we find them making great progress. At Silver City, Idaho, a Sprague motor is driving a 50-stamp mill four miles away from the generator. The latter, which gives off 75 horse-power, is driven by a turbine. It is stated by the manager of this mine that he saves on the haulage of his ore alone $90 per day.

At Veteran Tunnel, Aspen, Colorado, two sets of rope haulage drums are working with 10 horse-power Sprague motors, and a third is being erected. These draw six trams at the rate of 500 feet per minute up a 3 per cent. grade.

The Lykins Valley Coal Company, at the Short Mountain Colliery, Pa., in the autumn of 1887, started an electric locomotive which has since continued doing good work. The motor, a 25 horse-power Schlesinger, is connected to the locomotive wheels by chain gearing, and after six months' running the teeth of the pinion show but a wear of $\frac{1}{64}$th of an inch. It receives the current through a side conductor from a 50 horse-power generator, the length of the track is 6,300 feet, and it is hauling daily at a speed of from 6 to 8 miles per hour, some 500 tons per day.

The time taken to make an all round trip is about 14 minutes, as compared with 50 minutes when mule power was employed.

The most stupendous set of electric mining plant in existence, so far as the writer knows, is now working at Big Bend Tunnel Camp—Butte Company, California. A tunnel 16 feet by 12 feet and 2½ miles long is cut from the Feather River through the mountain. A permanent dam is built across the river just below the head of the tunnel by which the river is diverted from its channel and made to flow through the tunnel, thus drying up the bed of the river. A canal two miles long is constructed from the tail end of the tunnel by which a fall of 300 feet is obtained. Here powerful Pelton waterwheels are fixed driving the dynamos (Edison's). The working electromotive force is 1,000 volts. The conductors are double, metallic, and extend a distance of 18 miles, delivering electricity at 14 different points in the circuit where power is required for winding, pumping, &c. Some 10 to 20 Sprague motors, varying from 5 to 50 horse-power, are worked by branch conductors from these various stations. The potential at the motors varies from 500 to 700 volts. It is apparent where water power can be thus applied, the saving, when compared with the use of fuel, is very considerable, especially so in metal or diamond mining districts where coal is expensive. The ease with which any power can be conveyed over hill and dale, and into the intricacies of the mine, these are factors of no mean importance. It will be seen by this review of the more important applications of electricity to mining at present in existence how very little progress, comparatively speaking, has been made in this respect, and yet it is proving, in every instance where it has been adopted, a commercial success, and its application has invariably been extended. No doubt want of familiarity deters some engineers. They look upon electricity as a new idea, a something which cannot be explained, and as not to be relied upon when compared with steam, compressed air, water under pressure, and other well-known applications of power.

The drawbacks and shortcomings of these are admitted, but yet they are preferred because of their certainty of action and well-known properties. Many look upon electricity as yet in a transition stage; but it is not so. The efficiency of the machines is now so great, the price so moderate, and men of such high standing and repute are now engaged in their development that there need be no fear or hesitancy; electricity has passed beyond the range of theory and experiment. It is now a power in the world, and that power will increase mightily.

The writer will be amply repaid if by the perusal of this *résumé* any of his fellows are induced to take up the matter for themselves. He is satisfied that under many conditions common in mine working electricity can and will be applied successfully and economically.

REMINISCENCES OF AMPÈRE.

The city of Lyons is about to erect a statue in honour of the *savant* who discovered electro-magnetism. Prof. Cornu, of the Academy of Sciences, will show at the inauguration how greatly dynamic electricity is indebted to him. We will here merely give, from *Le Figaro*, a few facts concerning his private life.

André Marie Ampère was born at Lyons, in the parish of Saint Nizier, on January 22nd, 1775. His father was Jean Jacques Ampère, and his mother Jeanne Antoinette Sarcey de Sutières. Fifty-two years after his death Lyons has resolved upon raising a statue to its most illustrious son, who in his life-time was less honoured than he deserved.

The inauguration of the monument will take place in presence of the President of the Republic. M. Carnot, an old student of the Ecole Polytechnique, will thus render homage to the most eminent of its professors.

The childhood of Ampère was passed at Polymieux les Mont d'Or, near Lyons. Here, even before he knew figures, he made long calculations by means of pebbles and beans. He early displayed a wonderful memory and a prodigious power of assimilation. He devoted himself with equal and simultaneous ardour to botany and the study of Latin poetry. As he was also by nature a mathematician, we find him combining three distinct mental types. One of his earliest researches was the application of mathematics to games of chance. He proved rigorously that the professional gamester runs to certain ruin. This investigation of Ampère's, however, has probably not cured a single person suffering from the gambling mania.

His finest and most fruitful discoveries were made in physics. In 1802 the First Consul, Napoleon, offered a prize of 60,000 francs to anyone who should effect a similar advance in electricity or galvanism to that due to Franklin or to Volta.

Ampère was then engaged in researches which immortalised his name by leading him to the electro-dynamic theory. In a memoir communicated to the Academy of Science, in 1812, he already indicated the principle of electric telegraphy. In 1819, Oersted, of Copenhagen, discovered the action of an electric current upon a magnetic needle. This result became in the starting-point of one of the most beautiful inventions of the age. In eight days he conceived and realised the entire theory of electro-dynamics, and submitted his results to the Academy on September 18th, 1820.

The duties of an Inspector General of the University compelled Ampère to traverse France in all directions, and he had the curious habit of naming his theories from the places where they dawned upon his mind.

Great, however, as were Ampère's services to science, they would, doubtless, have been far greater if he could have kept himself from metaphysics. We know that in middle life Liebig bitterly regretted the time which he had devoted to such studies in his youth. Ampère, on the contrary, became more metaphysical as he grew older. He declined to answer a letter on physical and chemical topics which he had received from Davy, having, as he said, "no longer the courage to fix his ideas upon such troublesome things." He actually kept up a correspondence with Maine de Biron from 1805 to 1815, and he regretted that many of his friends did not care for metaphysics.

He was a believer in so-called animal magnetism, and admitted that in certain conditions of nervous excitement a man might see without eyes, and read a letter with his elbow. His mind was active only when standing. If seated at a table, pen in hand, his ideas vanished.

Ampère was exceedingly short-sighted, and, in addition, absent-minded.

Of the consequences of this defect some amusing instances are on record. On his appointment to a professorship at the Ecole Polytechnique he made his first appearance in the lecture-room in an old, ill-made coat, which became a standing joke among successive series of students.

Some of these young men pretended to be short-sighted, and by degrees persuaded the kind-hearted professor to write figures of such a size that the largest black-board would scarcely suffice.

One day, when absorbed in the development of a difficult theory, he mistook a duster, covered with chalk, for his handkerchief, and wiped his face with it accordingly.

Ampère was an intimate friend of Chevreul. They dined together weekly in the Rue de Babylone, with an American geologist, in company of La Reveillére-Lepeaux and Volney. Here was formulated the law of the simultaneous contrast of colours. In M. Chevreul's garden Ampère strayed at will, pursuing an idea, solving a conundrum, or catching butterflies.

Ampère was married in 1779, but had the misfortune to lose his wife as early as 1805, a calamity from which he never recovered. He passed entire days on the banks of the stream where he had first met her, and spent the time in making little mounds of sand. His death took place on June 10th, 1836, at the College of Marseilles.

The statue about to be inaugurated is said to recall very vaguely the features of Ampère. When questioned on this subject, the sculptor declared that this deviation from truth was intentional. The object was to ornament a beautiful square, and he therefore represented a handsome young man, an Apollo, which Ampère never was.

INTRODUCTORY ADDRESS ON THE ELECTROMOTIVE PROPERTIES OF THE HUMAN HEART.*

Delivered at St. Mary's Hospital Medical School, at the Opening of the Session, 1888-9.

By **AUGUSTUS D. WALLER, M.D.**, Lecturer on Physiology.

There is a growing disposition to regard introductory lectures as a survival—a survival unfit for the times. But, like all other customs, this custom, having had its particular reason of being in the past, lives on with altered ends and in changing shape. In its primitive shape, as a general guidance address to those who have just enlisted, it may be no longer necessary nor acceptable, but it certainly cannot be unfitting in any time that each member of a teaching body should in turn be called upon to say, in the presence of his fellow-workers, that which he thinks to be the best worth saying. My particular task on this occasion has been made easy by my colleagues; it was suggested to me that I should speak about physiology, and I am very willing to do so. Let me at once explain why.

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* Dr. Waller, who has kindly given us permission to republish his address in full (we gave an abstract of it last week) from the columns of the *British Medical Journal*, wishes it to be known that the electrical indicator referred to is Lippmann's capillary electrometer.—Eds. Elec. Rev.

The St. Mary's Hospital Medical School is at present rapidly growing, not merely in size, but in complexity; and it has within the last few years developed two entirely new organs, a physiological and a pathological laboratory. It is not unnatural that those who are most responsible for the development should be glad to hear something about the functions of these organs, and should expect from me, as the person responsible for the physiological laboratory, some report of progress during the last four years. I am, on my side, very willing that my duty as your introductory lecturer should take this form, which will allow me, not, indeed, to report progress in its full and formal sense, but to report on an item of progress; and I shall, therefore, occupy the greater part of the thirty or forty minutes allowed me in describing a new bit of knowledge, and how it has been obtained. Our new bit of knowledge is about the human heart, not in a metaphysical or figurative sense, not its motives, but only its action; not its power, but its electrical potential. Put into a single sentence, I am going to describe how the heart of man can be shown to act as an electrical organ, and what we learn from such action.

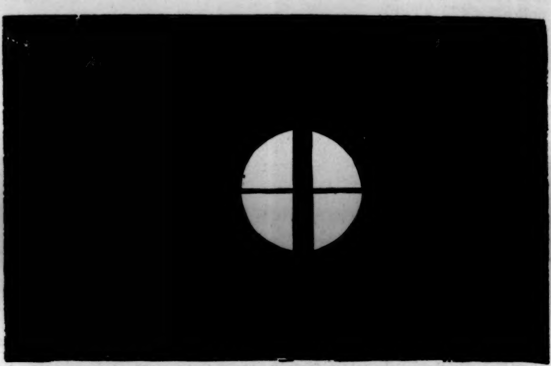
It is a well-known fact that every beat of the heart is accompanied by an electrical disturbance; the nature of this disturbance has, moreover, been studied and understood with the assistance of cold-blooded animals, and in this laboratory in particular an investigation was carried out to learn whether or no warm-blooded animals manifest similar electrical disturbances. These I will not now enter upon, and will only make the passing remark that, while to all appearance the electrical disturbances are similar in the two classes of animals, they are not identically so, these seem to indicate that the contraction, which at each beat of the cold-blooded heart runs down from the base to the apex, runs in the opposite direction in the warm-blooded heart. But this is only by the way, and I make no attempt to explain. It is to the next step that I invite your attention to-day, namely, to the human heart.

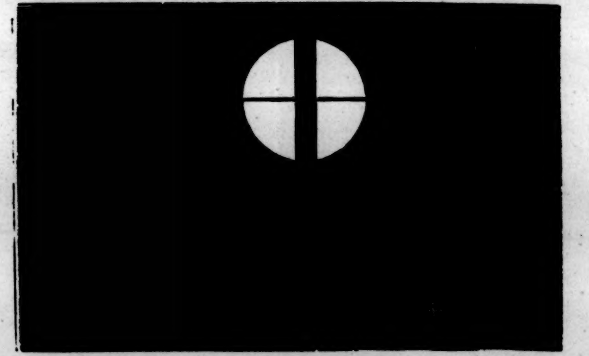
Led on from thought to thought it occurred to me that it should be possible to get evidence of electrical action on man by connecting not the heart itself, which is obviously impossible, but parts of the surface of the body near the heart with a suitable instrument; having verified this supposition, the next step was to see whether or no the same evidence can be obtained by connecting the instrument with parts of the body at a distance from the heart, with the hands or feet. The answer was, as you can well see, satisfactory. Finally, I tried whether two people holding hands and connected with the instrument, gave evidence of electrical shocks through each other, and I found they did.

The only portion which I wish to explain in any detail is the second step in these experiments, namely, the analysis of the results which are obtained when a single individual, whether man, horse, or dog, is connected with the electrical indicator.

Let me briefly explain the principle of action of an electrical indicator by referring to this diagram, in which the effects of water pressure are compared with those of what I may call electrical pressure (potential is the correct term, but I take it to be part of my task to-day to avoid technical terms).

A and B are two bottles of water, each connected by flexible pipes with a bent tube half full of mercury. If the two bottles are at the same level, the mercury in the bent tube remains at zero, and it is evident that this is still the case if both bottles be raised together or lowered together. But if the bottles be moved unequally, either up or down, the level of the mercury will alter. It is obvious that if A is lower than B, the mercury in this limb of the tube will move upwards, whereas if B is lower than A it will move downwards. And if we imagine everything hidden from us by a screen with the exception of this portion of the tube which we can view through a circular opening, while the two bottles are being moved by unseen hands, it is obvious that we shall be able to tell by the movements of the index whether A is below B or B below A. If the mercury goes up A is below B, if it goes down B is below A.



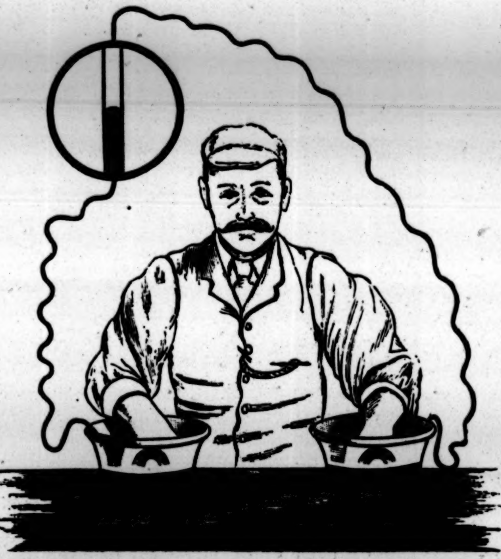


Now this is precisely what happens when the two ends of an electrical indicator are in connection with any two points, A and B, of a living body. If A and B are at the same level the index stands at zero, and it does not move if the two points are raised or lowered together to an equal amount. If the index moves up we know that A is lower than B, if down, that B is lower than A.

Let us now apply our instrument to the heart. This, which seems rather a bold proposition, is really a very simple and easy matter. We need simply dip the two hands into two basins of water which are in connection with our indicator, when we shall see that the mercury beats up and down with the pulse. These movements of the mercury are due to the electrical changes which occur with every beat of the heart; or we may dip a hand and a foot each into a basin of water with a similar result, only it must be the right hand, the left will not do. This difference, apparently so curious and puzzling at first sight, which seemed unsymmetrical and irrational, is in reality most reasonable, and proved to be the master key which threw open the meaning of every subsequent experiment. The difference depends upon the unsymmetrical position of the human heart, which is tilted to the left side somewhat, as shown in this diagram.

Allow me to return for one moment to the physical A B C of the subject. The points A and B are respectively applied to the apex and base of the heart; and if with contraction of the organ these two portions undergo any electrical change, the change will spread over the whole body in accordance with known laws. I will say no more than that. The form of the change is represented by these oval lines; if the electrical level falls at A it falls over the red area (see note and fifth diagram), which, as you see, includes the left hand and foot and the right foot. If the electrical level falls at B it falls over this blue area, which includes the right arm and the head.

Now it is obvious that the two ends of the indicator must be connected with A and with B before it will indicate any difference between A and B. If both ends are connected with A, or both ends with B, nothing will be seen. This was precisely what we got when the left hand and a foot were connected with the instrument, which begins to pulsate as soon as the right is substituted for the left hand. I might multiply instances, but will only just mention one. If the mouth and right hand are connected with the instrument, its index does not move, but it does so as soon as the left hand is put in the place of the right one. You must connect up a blue and a red point; two blue points or two red points are ineffectual.

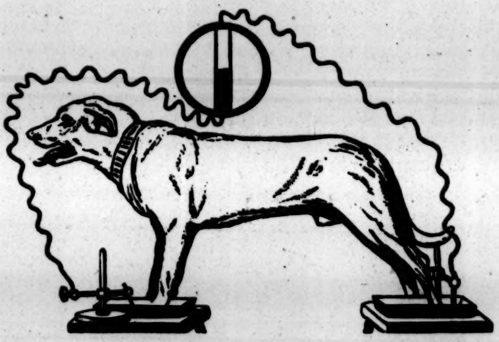


But this evidence does not stand alone. Cases every now and then present themselves with a transposition of the viscera, which are in such people situated just like those of a normal person as they would be viewed in a mirror. The heart, among other organs, is reversed, and, instead of pointing to the left, points to the right. As regards the electrical relations which I was following out, they were precisely as expected. The left arm was in this case the exceptional limb, and formed an effectual couple with any one of the other three limbs, but was ineffective in combination with the mouth. To make a long story short, the results were throughout as indicated in the diagram; any two blue points or any two red points in connection with the indicator were silent, but as soon as connection was made with a red point and a blue point then the index moved with each pulsation of the heart.

Let us hear one more witness. The heart of a quadruped (dog, or cat, or rabbit, or horse), is placed far more symmetrically than in man; it is very nearly in the middle line, so that the changes of electrical level whose foci are at A and B spread straight up and down the body, not obliquely, as in man. The upper half of the body is under the influence emanating from B; the lower half under that emanating from A. Unlike what occurs in man, the two front paws coupled with an indicator are silent, while either front paw taken with either hind foot gives us the now familiar answer.

These are the principal facts. What can we learn from them with regard to the normal action of the heart? I must be content with simply stating the answers.

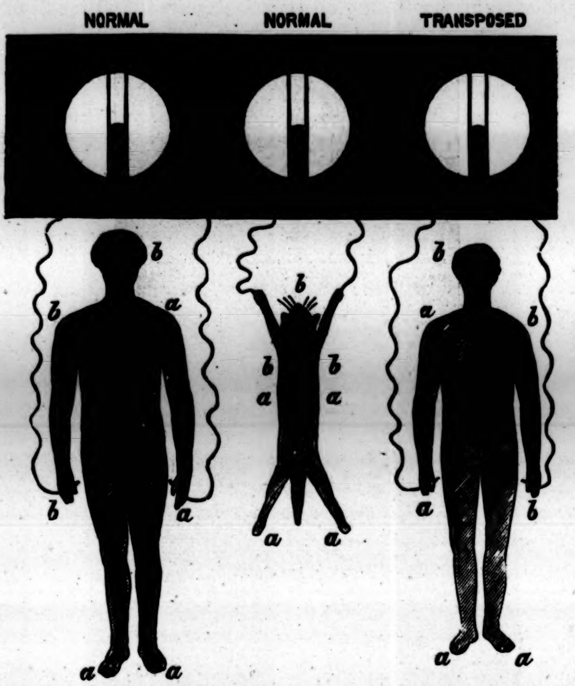
The fact that each beat of the heart gives an electrical change, beginning at one end of the organ and ending at the other proves that the contraction does not occur throughout the mass of the heart at one and the same instant of time; if the two points A and B rose and fell together, there would be no alteration of the index. The movements of the index show that there is a fall of A at the beginning of the contraction, and a fall of B at the end of the contraction. One of the most fundamental and certain facts in physiology is that the active state of a living tissue is marked by a fall of electrical level; in other words, an electrical depression is the best, most certain, and most delicate physical sign of physiological action; it proves the fact that living tissue is in excitement just as certainly as a dog's bark proves that a living dog is in excitement; A barks first, B barks last. In the contraction of the human heart the beat begins at the apex and ends at the base.



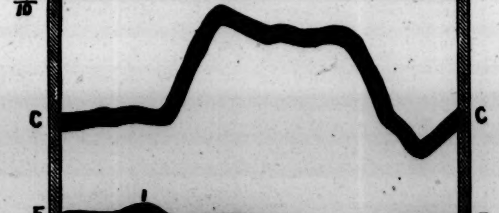
We have here the answer, and more than the answer, to a question which has often been asked but never settled—namely, does the heart (that is, the ventricles) beat simultaneously in every portion, or does the contraction take place progressively, as a state of action traversing the whole mass from a beginning to an end? The answer is a distinct affirmation of the second alternative to the exclusion of the first, with the additional and unexpected rider that the contraction begins at the apex and terminates at the base.

I have tried to sketch out in language as little technical as might be the scope and outcome of a physiological research. I fear—nay, I am sure—that to many of my audience it has been dry and tedious, yet I cannot but hope that some of you have been interested to hear by an actual example what kind of work goes on inside a physiological laboratory. That has been on the learning side. I should like to touch upon the teaching side.

We may take for granted the importance of physiology in medical education; you have, apart from all higher considerations, a very prominent and tangible sign in the still growing requirements of every examining board, on the Embankment as well as at Burlington House.



Your chief stumbling-block is in the indefiniteness of the subject. You are expected to show that you understand certain sequences and relations between the chief functions of the human body, and that you remember a list of facts, laws, numbers, formulæ, and German opinions. Now, it generally happens when a man sends in his schedules that he distrusts his memory rather than his understanding; but I am well assured that failures are far more due to unconscious errors of understanding than to conscious errors of memory. What I have termed the sequences and relations in physiology are the silent river; the strings of letters, figures, and words are the brawling torrent! This is exactly as it should be, for the silent stream is a better test of a man's swimming capacity than the shallow torrent.



C C = cardiogram. E E = electrometer tracing. *t t* = time in tenths of a second.

To drop metaphor—the great sequences and relations between the parts of a living body, by their very indefiniteness, form the best possible ground on which to test judgment and acumen before memory, just the qualities by which you will have some day to distinguish, weigh, and guide physiological factors which hang together labelled with the name of a disease.

If you learn to see clearly and to move freely in the half-lights of physiology you will see better and blunder less when you have to act in the quarter lights of medicine.

I do not intend to refer in any great detail to particular examinations, but, still confining myself to physiology, I will allude to them for a particular purpose. The first and second examinations of the Conjoint Board are the first two tests which you all submit to, and I think it is becoming more and more your custom not to give a very bulky precipitate of failures from St. Mary's. I gather from the Dean's statistics that the St. Mary's share of the precipitate is very small in comparison with that which it contributes to the filtrate. Taken all in all, the tests are reasonable; the quality of book knowledge and of practical work required is sensible and moderate.

But, London? It would appear as if the regulations for the intermediate M.B. were designed with the special purpose of preserving the ordinary London graduate from any practical acquaintance with physiology. The regulations set forth that practical work in physiology is required only by candidates for honours, and not by candidates for the ordinary pass. A little further, under the heading of organic chemistry, they supply the astonishing item of information that an estimation of sugar or of urea may be required in the honours examination.

As if still further to ensure that the ordinary candidate may have a fair chance of muddling his physiology by neglecting it in season and cramming it out of season, when his whole attention should be concentrated on medicine and surgery, the regulations provide that "any candidate shall be allowed . . . . to postpone his examination in physiology . . . . until the next or any subsequent year."

The effect of these regulations upon the study of physiology is very unfavourable. You know only too well that practical physiology is not wanted at the examination, and you do not believe that it is wanted for the examination quite apart from any ulterior value it may possess to you. You look upon practical physiology as a luxury and you do without it. You are told that an estimation of urea or of sugar may be required at the honours examinations, what more natural than that a pass candidate should think it ridiculous waste of time to learn to estimate sugar and urea by doing so when he can read about it in any book? But I would have you remember this, that although the London University by implication advises you so badly, yet it does not expect you to act upon the advice—quite the contrary. Although as a matter of convenience, practical work is not wanted at the pass examination, there is no examination at which its value is more felt, both in the written paper and still more at the *viva voce* interview which follows it. The reason is obvious; the examiners you have the pleasure of meeting there are men whose lives are spent in laboratories, and whose conversation when you meet them at Burlington House is apt to be more practical than scholastic. To put it low, book talk, unleavened by any memories of the laboratory, does not pay; and as for the written paper—well, fireside anatomists are not apt to give very clear or very correct descriptions; fireside physiologists write perfect balloons of unsubstantial statements.

I have seemed to make examinations the end-all of your students' career, but I need hardly say that I look beyond them; the proof of a picture is in the selling of it; the proof of a student is in the passing of him. These are rough tests which mark out good pictures and competent men. I should hardly have made such a point of practical physiology had I not been convinced that its importance extends beyond as well as up to the time when a man receives his certificate of competency to take charge of lives and limbs.

I would have you convinced from the very outset of your medical studies that examinations and competency in after life are on the same lines—the same road leads to both, and to the success which is the natural and lawful reward of competency. It is the royal road of actual contact with facts which temper men as fire tempers steel. Your way lies through the dissecting room, the laboratory, and the hospital ward, more than through the lecture room and the printed book. It is something, no doubt, to be learned, to be well filled with the knowledge of what other men have thought, said, and done; but mere learning is an invertebrate; contact with facts gives it backbone, and makes all the difference between the bookworm and mental vertebrate man. And it is the same royal road that leads on to that well-grounded consciousness of power, to that fertility of practical resource in the face of danger; above all, to that "never say die" spirit, which is the best of drugs—best for your patients, best for their doctors, best, indeed, for every man and woman with duties and purposes to fulfil.

Note.—The diagrams used in the lecture were in red and blue. In the woodcuts as printed, red is light shading, blue is dark shading. In the third diagram red is in plain lines, blue in dotted lines.

NOTES.

Erratum.—An error occurred in one of the foot notes to Mr. Legh Powell's article in our last on "Different sectional heating of incandescent lamp filaments." In the second line of the first foot note at the bottom of the second column of page 366 "3—5 watts" should have been "3·5 watts."

Electric Lighting in Paris.—The Municipal Council of Paris on the 27th of last July offered to public tender three contracts for the construction and installation of, (1), electrical machines and apparatus; (2), motors; (3), steam engines, for the lighting of the Halles Centrales. Two special commissions will meet at the Hotel de Ville to decide upon the admissions to the competition of the various proposals:—(1), on October 25th for the electrical machines and apparatus; (2), on October 26th for the motors and steam engines.

Electric Light in Milan.—The "Société Générale d'Electricité" of Milan appears to be in a flourishing condition notwithstanding the keen antagonism of the Gas Company. The increase in receipts for the year 1887 as against 1886 is about 2½ times greater than the corresponding increase in expenditure for the same period. In 1886 the company owned 9,450 incandescence lamps and 154 arc lights; in 1887 these figures had increased to 11,000 incandescence lamps and 218 arc lights. During the same period a large sum was expended in relaying the conductors through the streets, so as to render them perfectly safe for the future. It appears that this proceeding was necessitated owing to the original protection or covering of the wires being insufficient.

Electric Light in Vienna.—The electric light installations in Vienna have occasioned, during the last year, a large increase in the consumption of gas, due to the extensive employment of gas engines in electric light plants. Of the principal installations Messrs. Siemens and Halske have put up 31; Messrs. Bruckner, Ross and Cons, 11; Messrs. Krementzky, Mayer & Co., 14; and Messrs. B. Egger & Co., 10.

Mill Lighting.—A very successful installation has been completed at the three mills of the Slaithwaite Spinning Company at Huddersfield. There are about 170 lights in two rooms of No. 1 Mill, 80 lights in one room of No. 2 Mill, and 180 lights in the lodge, scutch room, and two rooms in No. 3 Mill. The installation has been fitted up by Messrs. J. H. Holmes & Co., electric light engineers, Newcastle-on-Tyne. "Castle" dynamos, compound wound, self-regulating, slow speed, have been used to supply current.

The Hague Electric Light Company.—This association has erected two central stations, and has laid cables throughout all the principal thoroughfares. It now announces that it is prepared to supply private houses, shops, &c.

The Electric Light at Barnet.—The lighting of the streets of Barnet by incandescent lamps comes in for some very sharp criticism by the representative of the *Blyth Examiner* who recently visited the town. The writer's conclusion is: "Nothing, I think, could very well be worse as a means of street lighting." At last week's meeting of the Local Board the clerk intimated that he had received numerous letters of complaint respecting the lighting of the district.

Leamington and the Electric Light.—At the monthly meeting of the Leamington Town Council on Monday, a letter was read from the Midland Electric Light and Power Company offering to erect four arc lamps in the Parade for £12; to place five 300-candle-power incandescent lamps on five existing lamp-posts for £18; and to place twenty-five 50-candle-power lamps in the place of twenty-five of the existing candle-power lamps for £3. The company would contribute one-third of the cost and supply the extra current without charge. The Deputy-Mayor moved the acceptance of Messrs. Chamberlain and Hookham's terms. Mr. Crowther Davies seconded the motion, which he regarded as the beginning of the end of all differences between the corporation and the contractors. The latter had met the corporation in a manner which reflected the utmost credit upon them. Neither he nor any of his supporters were desirous of getting rid of the Electric Lighting Company. All that they desired was to get rid of the present inefficient system, and introduce one which would be a credit to the town and the company. The council were indebted to the Mayor for bringing about this desirable result, and also for offering to erect the poles of the arc lights. He had no doubt that the experiments which were about to be conducted at such a small expense to the ratepayers would prove completely successful. Mr. Barter White moved, as an amendment, that Messrs. Chamberlain and Hookham be requested to present an estimate of the cost of carrying out the alterations involved in ther alternative system, and also to state the permanent charge for the additional current. Mr. Orton seconded the amendment, which was lost; and the council agreed to the terms offered by the Midland Electric Light Company for carrying out the contemplated tests, which are to be made without prejudice to the existing contract.

St. George's and the Electric Light.—At the meeting on Thursday last week the Vestry of St. George's proceeded to appoint an Electric Light Committee, in accordance with a resolution passed at the last meeting. It was agreed that the committee consist of thirteen members, and that the following gentlemen, who were members of a former committee, be elected members, viz.:—Mr. John Dovey, Admiral the Hon. A. Duncombe, Sir William J. Farrer, Lord Frederick Fitzroy, Lord Hobhouse, and Admiral Sir George Wellesley. The following gentlemen were also elected:—The Hon. Alan de Tatton Egerton, M.P., Mr. Southon, Mr. Cove, Mr. Antrobus, Mr. Williams, Mr. J. Finch, Mr. Adkins.

Paddington and the Electric Light.—At a meeting last week of the Paddington Vestry, the Finance Committee recommended that a special meeting be held to receive and consider the approximate estimate of assets and liabilities for the half-year ending Lady Day, 1889. Mr. Mark Judge asked that the Electric Lighting Committee's report should be considered first by the joint committee then meeting, as the subject was of great importance to the parish. The Electric Lighting Committee, having considered the report of Mr. S. J. Mackie, thought it would be to the interests of the parishioners to take the necessary steps to apply for a provisional licence for electric lighting this year. This was agreed to.

The Electric Light in a Royal Palace.—The Palace at Sinaia, where the Prince of Wales is just now receiving the hospitality of the King of Roumania, is superbly situated among the mountains within sight of the line of railway between Vienna and Constantinople. Every room, from basement to attic, is lit by electricity, the motive power for which is provided by one of the many mountain streams found in the neighbourhood.

Says a London correspondent of provincial papers :—I happened to be in the Palace of Sinaia when the electric light was being exhibited to the King on trial. The representative of the English firm who was setting up the installation was an exceedingly voluble person, and he was explaining to his Majesty at great length all the advantages which the electric light enjoyed over gas. It did not tarnish gilt, it did not consume or vitiate the air, it could be turned on or off at any moment; there was no occasion to use matches, and, greatest advantage of all, it minimised the chances of fire, and absolutely gave out no heat. The King listened with great attention and was evidently much impressed, but just as the voluble gentleman was mentioning the fact about there being no heat, he placed his hand at the bottom of one of the lamps, and even the Royal presence could not restrain an exclamation of pain—he had burnt his fingers with the heated metal. Seeing this, the King gingerly touched the lamp in turn, and he, too, got a slight burn. He smiled grimly, and, turning to the electrician, said :—"Hum, well. I hope, Mr. ——, all the other advantages of the electric light are not so apocryphal as this." But he decided to have it installed all the same.

Chelsea and the Electric Light.—At the last meeting of the Chelsea Vestry, the Electric Lighting Committee reported the receipt of an application from the Chelsea Electricity Supply Company for permission to add to the area in which it is already empowered to supply electricity, certain other districts, including first, the Leete Street Estate; secondly, that part of the parish between King's Road and the Embankment; and thirdly, Elm Park Road. The committee recommended :—"That the Board of Trade be informed that the Vestry dissents from the application of the Chelsea Electricity Supply Company, for the extension of Schedule A, at the present time; and that the Board of Trade be further informed that the company has not exercised any of the powers of its order as to the existing Schedule A, as far as regards the execution of works therein." Mr. Mossop moved the adoption of this recommendation. He explained that under the order the applicant company was required to deposit with the Vestry the sum of £2,000 before commencing its works in the first part of the district, being that included in Schedule A. This it had not done, and until it made some practical step towards commencing operations in that part of the district, he thought it would be unwise for the Vestry to permit any extension of the area of supply. Mr. Oakeshott seconded the motion, which was carried unanimously.

Leeds Wants More Light.—The *Yorkshire Post* says :—"Mr. Morton Latham makes an excellent suggestion *apropos* of the Whitechapel murders, a suggestion which is as true of most of these Northern towns, and particularly of Leeds, as it is of London. It is that if every street were well lighted, and every court and alley were brilliantly lighted, deeds of darkness would be diminished and morality promoted. It was estimated in New York that every street electric lamp saved one policeman, and was less expensive to maintain, and that, we believe, would be the case here if we could only adopt the electric light in our public thoroughfares, or if we could only make good gas and use it freely. The lighting of most of these Northern towns is a scandal and a reproach—and in none is it worse than in Leeds.

The Telephone in Holland.—The Dutch Government has granted a concession to the Bell Company for the long distance telephone.

Theatre Lighting.—The Colon Theatre in Buenos Ayres has been lately completely fitted up by the Edison Company with incandescence lamps. The original installation comprised only 180 incandescence lamps and one arc light, employed for stage lighting and scenic effects and for illuminating the passages, &c., behind the scenes.

A Correction.—In Mr. Alexander Watt's paper on the "Electrolysis of Tin Salts" in our last issue, the figs. 7 and 10 in the illustrations should be reversed, the last illustration being referred to as fig. 7.

A "Burn-out" at Columbus, Ga.—A telegram from Columbus, Ga., of September 11th, says :—The telephone wires and the electric light wires became entangled last night, while a full current was on the electric light wires. The telephone wires were melted, and night operator W. H. Galloway had a narrow escape as the current communicated with the central office. He had the head telephone on at the time, but prompt action on his part saved his life. The head telephone and the call-wire switchboard were destroyed.

New York Street Cars.—The *Electrical World* says it is impossible to exaggerate the importance of the work now being done on the Fourth Avenue in New York in the introduction of electric street cars. There are many features special to this piece of work, giving it unusual prominence and significance. New York city, to begin with, is peculiarly suitable for demonstrations of an improvement of this character, and our firm conviction is that the more the public see of the storage cars the more they will insist upon having them. So far as the public is concerned, the element of expense does not enter into the matter any more than it does into the agitation against bobtail cars. It is enough that the cars are swift, clean and safe, easily controlled, do not in the slightest degree affect the paving of the roadbed, save the horses from a cruel fate, abolish the malodorous car stables, lighten the work of the drivers, and are free from all the objections that can be raised against either the steam elevated road or the surface cable cars. On the other hand storage cars *are* cheaper than horse cars to run, and that is the main point for the operating companies; while there is another enormous advantage in the fact that the change from the old system to the new can be made gradually. Then, again, the adoption of storage for such a road as the Fourth Avenue is a very hopeful and cheering sign, not only of the liberal policy marking the Vanderbilt régime of to-day, but of the prospects of electricity in urban passenger traffic generally. If storage cars thus find favour with one of the largest and most conservative managements in the country, one may well be sanguine as to the future.

The Proposed Electric Tramway in the Isle of Wight.—The conditions, some 17 in number, upon which the Corporation of Newport will consent to the running of an electric tramway between that town and Carisbrooke having been settled, there is every probability that the line will shortly be commenced. Public opinion in Newport is decidedly in favour of the innovation, but some opposition has been encountered on the part of certain residents at Carisbrooke, who seem to imagine that they have a prescriptive right to be kept free from contact with the "madding crowd," and are afraid lest the proposed tramway should unduly popularise the ancient ruins in their locality. At a vestry meeting which was held last Thursday at Carisbrooke for the purpose of considering the question, a majority of four votes decided in favour of the tramway.

The Telephone in Havana.—Havana is apparently an exception to the general development of the telephone system, as the number of subscribers has been steadily falling. In October, 1883, they were 555. In the same months of following years they were :—1884, 502; 1885, 459; 1886, 429; 1887, 3:3; 1888 (August), 348.

Electrical Pleasure Boats.—The first public pleasure boat to be driven electrically on the River Thames was launched on Monday. It is 65½ feet long, 10 feet beam, and designed to carry 80 passengers, at six miles an hour, as regulated by the Conservancy bye-law. The electrical machinery and storage cells are placed below the deck fore and aft, leaving a clear run the whole length of the boat for passengers. In the middle is a handsomely-fitted cabin with lavatories, dining-table, &c. The electrical energy is stored in 200 E.P.S. accumulators, and is converted into motive power by two motors of 7½ horse-power each, driving twin three-bladed propellers by Thornycroft and Co. The launch is owned by Messrs. M. Immisch and Co., by whom it was built, under the direction of Mr. Sargeant, whose letter, which appears in another part of these columns, will give some additional information on the subject.

Watt v. Maxim-Weston Electric Company.—The action brought by Mr. Hugh Watt, M.P., against the Maxim-Weston Company for rectification of the register and the petition by the same gentleman for the compulsory winding up of the company, came before the Vacation Judge, Sir James Hannen, on Wednesday, when both were postponed till the next sittings.

Indo-European Telegraph Company, Limited.—Mr. J. Herbert Tritton has been elected chairman of this company in succession to Colonel Holland, who has retired owing to his advanced age.

Parts of Steam Engines.—Messrs. Tangyes, Limited, have just issued a catalogue which we believe is the only one of the kind ever compiled. The firm claims to have the largest and most varied stock of steam engine patterns in the world, and the catalogue has been prepared with a view to meet the wants of any who may wish to purchase parts of steam engines, either in the rough casting or forging, or partly or wholly machined. It often happens that where there is the necessary machinery for turning out work of a special kind, there are neither the patterns nor particular tools required for economically and efficiently making, say, a steam cylinder or some other part of a steam engine, and castings have to be purchased and machined generally with a result anything but satisfactory. With this list of cylinders, pistons, crossheads, connecting rods, eccentrics and other parts anyone may at once procure what is needed, with the assurance that by ordering from a firm engaged from day to day in the manufacture of these special articles, they will be found of satisfactory design and finish. The Tangye-Johnson automatic cut-off gear is also described in this catalogue.

The French Telegraph System.—M. Caël, the Directing Engineer of French Telegraphs, has recently submitted to the Administration of Posts and Telegraphs a report upon the speeds of transmission obtained from the various instruments in use on the French telegraph system. We notice that the high-speed appliances consist chiefly of the Wheatstone, the Hughes, and the Baudot instruments. The average speed per minute per *employé* has been found to be on the Hughes 8 words, on the Baudot 11·2 words, and on the Wheatstone 13·3 words. The quadruplex Baudot is preferred to the other instruments since it is faster than the Hughes, and has the advantage over the Wheatstone in that it prints the signals in Roman characters.

Damage from Lightning.—The telegraph line between Wittower and Arkona (Island of Rügen) was recently struck by a flash of lightning at about 5 kilometres from the first-named town. Several posts were destroyed and the wire melted for a considerable distance, the current after shattering an ebonite insulator outside the office in Wittower passing to earth. It appears that a portion of the discharge passed through the office, but thanks to lightning protectors occasioned no damage.

Electrically Refined Sugar.—Prof. Silvanus Thomp- has written to the *Times* upon this subject as follows:—"In these days, when the mere prefixing of the word 'electrical' to a process or invention is sufficient to attract attention on the Stock Exchange and in the public press, it may not be unimportant to point out that the persons who have introduced into this country samples of sugar refined by the method devised by the late Mr. Friend, of New York, have produced no evidence whatsoever that electricity has anything to do with the process. The chemistry of sugar refining is briefly this—that the syrup requires to be partially oxidised, and strained or filtered to free it from impurities. Far be it from me to deny that oxidation can be effected by electric discharges. Granted that this can be done as a matter of experimental science, there still remain three questions—Can the process be made a commercial one? Is such a process cheaper than the older chemical processes for attaining the same end? Lastly, but not of least moment, Have the samples of 'electrically refined' sugar been, in fact, produced in this way? I am aware that a certain section of the public prefers to take such matters on faith. As a scientific man I must be permitted to be sceptical until proof is forthcoming."

A Submarine Torpedo Boat.—The *Daily News* Paris correspondent states that experiments are being made on the Seine, near Issy, with an electrical and submarine torpedo boat made for the Minister of the Navy and at his own expense. This engine of war is constructed of sheet iron, shaped like a cigar, having a length of 4 metrès 50 centimètres, and a diameter of 1 mètre 60 centimètres. Its electrical current is generated by Schanschieff batteries. The motor is a dynamo of Edison's of a new sort, light and compact. This boat can be made to dive and to take an undulating course in the water. Large scissors project from the prow, which are intended to cut torpedo wires. They are worked by machinery from within. Compressed oxygen is stored in tubes of peculiar construction, and in sufficient quantity to make it easy to keep the boat some time under water. This model has been obtained from Russia. It was adopted by the Russian navy a short time ago after it had been tested at Cronstadt.

Telephone Line.—The German Administration of Posts and Telegraphs is engaged in the erection of a bronze wire telephone line between Breslau and Berlin. The section between Tiegristey and Grunberg was completed on the 27th of last July, the tests proving extremely satisfactory.

Telephone in Portugal.—We understand that the Portuguese Government has commissioned MM. Mourlon et Cie., of Brussels, to supply all the material necessary for the construction of a telephone line between Lisbon and Porto.

Long Distance Telephony.—The telephone line between Berlin and Dresden, a distance of 105 miles, was recently opened to the public. The cost of a five minutes' conversation is 1.25 francs.

Blyth and the Electric Light.—On Monday a public meeting of the ratepayers of the Cowpen township, Blyth, was held in the Market Place, Waterloo under the auspices of the Cowpen Local Board, to take into consideration the advisability of lighting the Cowpen township with electricity. Having heard the estimated cost of lighting by electricity and by oil the meeting unanimously agreed to urge upon the Local Board the advisability of adopting the electric light without further delay.

The Taunton Electric Lighting Company.—Mr. Orlando V. Thomas has accepted the appointment of electrician-in-charge to the Taunton Company, Mr. G. S. Hooker having resigned to take charge of the Bath installation.

Transmission of Power.—Certain Basle and Zurich capitalists are endeavouring to float a scheme for utilising the waters of the Rhine, by means of a canal some 2½ miles long, the water-power obtained being estimated at 3,500 H.P. It is proposed to electrically transmit the power to consumers, and it is calculated that a profit of 8 to 9 per cent. would be realised on an original outlay of some £400,000.

The Schanschieff Primary Battery.—A company has been brought out in Australia under the title of the Victorian Schanschieff Electric Light and Power Company, Limited, with a capital of £100,000 in £1 shares. The Australian patents were secured by Miss Alice Cornwell when on a recent visit to this country, and that lady, who has, we believe, direct business connection with Mr. D. Marks, of the English Schanschieff Company, now figures as the vendor, receiving £30,000 for what she has to sell, payable by a bill at four months for £20,000 and 10,000 fully paid shares. Our own views respecting the Schanschieff battery have often been expressed. It is an excellent one in its way, and Miss Cornwell deserves some reward for her pluck in securing the patents and the energy which she has displayed in introducing the battery to the Australian public. If she succeeds in getting the remuneration above mentioned we need scarcely say her reward will be more than ample.

The Retort Courteous.—It has been reported that the electric light which should have been forthcoming in the Avenue Theatre on a certain evening last week was unavoidably delayed through a strike amongst the workmen at the Whitehall Central Station. Other information having come to hand that this statement was erroneous we, early in the week, sent a polite note to the secretary of the Metropolitan Electric Supply Company asking for the actual facts of the case. To this we receive, as we are going to press, the following communication signed by Mr. J. E. H. Gordon:—"Our secretary has handed me your letter. If you had taken the trouble to call at the theatre any evening for several days past you would see that it is regularly lighted. I would suggest your time would be better so occupied than in enquiring into matters which concern only ourselves and our men." Now, to characterise this effusion as impertinent would be putting upon it but a mild construction; to think that Mr. J. E. H. Gordon could have been in his normal state of mind when writing would be inferring that he had unfortunately become, like Messrs. Jay Gould, and Garrett, bereft of reason through the fearful strain which dabbling in electrical matters imposes even upon stronger brain powers, and to imagine that it faithfully represents his company's feelings would be but an insult to that august body. Has electric lighting, with Mr. J. E. H. Gordon posing as the autocrat of electrical supply, come to such a pass that the public weal does not now enter into the question at all? We really think that in the interests of suppliers and consumers Mr. J. E. H. Gordon should secede from business altogether and pass the remainder of his days in the quiet and unostentatious manner of a perfect gentleman, a position he is so well-fitted to adorn.

Personal.—The *Municipal Review* for October 6th contains a capital portrait and an appreciative biographical notice of Mr. H. G. Massingham, of Bath, the pioneer of the electric light in Taunton.

Science Education.—At the inauguration of the sixth session of University College, Dundee, Prof. Ewing delivered an able and stirring public address upon the whole duty of the student.

Another Theatre Burnt.—The Theatre of Varieties at Dundee, which was to have been opened after undergoing repairs on Monday, was burnt down early on Saturday morning. Fortunately no lives were lost.

Underground Telephone Cable.—The Kinetic Engineering Company writes:—"In reference to the note in your current issue upon the telephone in Switzerland it may interest your readers to know that the type of underground cable chiefly used for this purpose consists of one manufactured under the Berthoud-Borel patents, in which not only is the whole cable contained in a double sheathing of lead, but each conductor is covered by a single sheathing of this metal, which is used for the return circuit. In such favour is this type of cable held that during last year alone the Swiss Government took delivery from the Berthoud-Borel factory and laid underground no less than 950 miles of this type of conductor grouped in various sized cables. The Austrian Government is also a large user of this type of cable, having already laid more than 375 miles of such conductor."

Reuter's Telegram Company, Limited.—Admiral the Right Hon. Sir John C. Dalrymple Hay, Bart., K.C.B., has been elected chairman of this company in succession to Colonel Holland.

The Electric Launch Controversy.—The following letter has just reached us, but too late to appear in our Correspondence Columns:—"A notice of the launch of the *Viscountess Bury*, built by me for Messrs. Immisch & Co., having appeared in the daily papers, I regret to find that an attempt is being made to filch from me the credit of the design, construction, &c., of that boat. I appeal to your well known reputation for seeing fair play to allow me to place the facts shortly before the electrical world. My profession, as is well known on the River Thames, is that of architect and designer of boats of all kinds. Messrs. Immisch and Co. were introduced to me by a mutual friend with the object of my designing electrical boats for that firm, among my other professional duties. The first work of consequence between us was the *Malden* electrical launch. I not only designed her, but also superintended the construction of that boat. The floating charging station was the next work which I carried through for them, and for that from beginning to end, I arranging everything. Lastly, the *Viscountess Bury* was built at my suggestion, and everything from stem to tafrail was designed by me, including the electrical arrangements. I may add that full control was left in my hands, I paying my own cheques and money for most of the material and expenses, and Messrs. Immisch and Co. returning the amounts disbursed from time to time.—W. S. SARGEANT."

Photographing Lightning.—In the last number of the *Comptes Rendus* M. Ch. Moussette has a short note on the precautions which it is necessary to take when photographing lightning flashes. Most of the peculiarities noticed in photographs of this description arise from accidental vibrations caused by the wind, the thunder, or the shaking of the earth. In order to prove this, M. Moussette made a white on black drawing of flashes inclined at different angles. This drawing was photographed in two ways; firstly, with the camera carefully secured from vibration; secondly, with the camera slightly jerked at the moment of photographing. In the first case the flashes came out fine and clearly defined; in the second case the flashes presented the appearance of striated ribbons, except where the lines of the drawing were parallel to the direction of motion of the camera.

Boston and Electric Street Railways.—In an article eulogistic of Boston learning and Boston enterprise, *Modern Light and Heat* expresses surprise that whilst the city has, in a general way, kept well to the fore in electrical matters, it has lagged behind in the matter of electric street locomotion, notwithstanding that it boasts of the possession of the most extensive street railway system in the world. The West End Street Railway Company has, however, as we recently notified, determined to adopt electricity as its motive power.

The Copper Market.—Copper shows no sign of falling yet, the price is maintained, and stock is gradually increasing. In England and France the stock was about 5,000 tons greater at the end of September than at the close of the previous month.

Applied Mechanics Questions.—This collection of questions, by the Professor of Engineering in the Glasgow and West of Scotland Technical College (with answers to some), is divided into three distinct sections, elementary, advanced, and honours, and each of these sections is again sub-divided and arranged in a natural order under sub-headings, so that a lecturer on applied mechanics or a student may have as little trouble as possible in selecting suitable examples. These questions, which extend over 33 closely-printed pages and number nearly 400 examples, should form a great and much needed help to engineering students studying for the Science and Art and City Guilds of London examinations, and no teacher or student of applied mechanics should be without a copy. They are neatly printed, and published at 8d. by Messrs. John W. Morgan and Co., 129, Sauchiehall Street, Glasgow.

Gas at Stockton.—At the monthly meeting of the South Stockton Local Board, a letter was read from the Town Clerk of Stockton stating that the Corporation could not see its way to accede to the request of the Local Board for a reduction in the price of gas to South Stockton from 2s. 8d. to 2s. 6d. per 1,000 feet. Mr. Steel moved the appointment of a committee to consider the question of lighting South Stockton by gas or other means. Mr. Lee seconded, remarking that several smaller towns were lighted by electricity. The Clerk (Mr. Dodds, M.P.) said that the Stockton Gas Act of 1857 gave the Stockton Corporation the exclusive right to supply gas in the Local Board district, but he could not say how it would affect the Local Board's power to supply any other illuminant. Mr. Steel withdrew his motion, and the Clerk was requested to report as to the Board's power.

The Distribution of Electricity.—The technical electricity evening course at the Yorkshire College was opened on Monday by a lecture on "The Distribution of Electricity," by Prof. Stroud, D.Sc. The purpose of the lecture was to consider what has been done in regard to the distribution of electricity during the last ten years. Various systems, such as the Edison-Hopkinson three-wire system, were described, and allusion was made to the immense progress that has recently been made by the employment of high pressure in mains and low pressure in houses by utilising the transformer principle.

Improved Gas Lighting.—It is reported that Mr. Sugg has made a discovery by which the harmful products of combustion are carried off, and the air of the room is kept free from the ordinary contamination of burning gas.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Buenos Ayres Electric Light Company, Limited.—The annual return of this company, made up to December 30th, 1887, was filed on the 3rd inst. The nominal capital is £100,000, divided into 9,986 shares of £10 each and 70 founders' shares of £2 each. The company was registered in 1881, but the only shares allotted are the founders' shares, and upon these no call has been made or paid. Registered office, 1, East India Avenue.

Southampton Electric Light and Power Company, Limited.—The statutory return of this company, made up to the 27th ult., was filed on the 2nd inst. The nominal capital is £30,000, divided into 4,000 preferred and 2,000 deferred shares of £5 each. Only 8 shares are at present taken up, and upon these no call has been made. Registered office, 23, High Street, Southampton.

CITY NOTES.

Eastern Extension, Australasia, and China Telegraph Company, Limited.

The thirteenth ordinary general half-yearly meeting of this company was held on Wednesday at Winchester House, Old Broad Street, Sir John Pender, K.C.M.G., chairman of the board of directors, presiding. The chairman, in moving the adoption of the report, said it was satisfactory to find that the gross receipts showed an increase of upwards of £20,000 over the corresponding half of 1887, while the working expenses at the same time showed a decrease of nearly £7,000. Of this, £4,000 was saved in the cost of repairs, an item which must always be a fluctuating one, and the remainder was spread over the general working. An interim dividend of 1¼ per cent., amounting to £31,250, had been paid during the half year, and another of like amount would be distributed on the 16th inst., leaving £47,903 to be carried forward, after charging £15,410 against revenue for repairs to the Singapore cable. A shareholder had addressed him on the subject of the bonuses which he thought ought to be paid each half-year; but the shareholder seemed to have overlooked the fact that the question was fully gone into 18 months ago, and the board then decided that bonuses should only be paid after they had made up their accounts at the end of each year. That policy they had adhered to, and there was every justification for doing so. By doing this and carrying forward a large amount they maintained in the market a more uniform rate for their shares. Those who held their property as permanent investment had the satisfaction of seeing it increase in value rather than decrease, and those who were disposed to sell at particular periods of three or six months got a higher market price than they would if the reserve was smaller, and smaller amounts were carried forward. Another reason for adhering to this custom was that they were liable to interruptions, and in the past six months they had two serious interruptions to their Australian systems, due to volcanic action, the result of which was that for 19 days they were without any communication with Australia. That might have had the tendency of causing almost a panic in regard to their property but for their very large reserve; but, as it was, the difficulty was passed without any material difference taking place in the value of their property. A curious thing was that when they picked up the cable they found all sorts of things near it, even roots of trees: so that there must have been a great upheaving of nature. Without hesitation they decided to lay a third cable, so as to prevent any total interruption in future. The policy of the company was to do their work in such a way as to command the complete confidence of the public, and when they saw that anything could be done to strengthen the permanency of their system they did not fail to do it. The new cable would add immensely to the present existing land system in Australia, and would give an alternative and much more efficient system of communication with the colonies. It was being laid with the approval of the Home and Colonial Governments, and it would do much to stop the threatened competition of a line from a point in Western Australia to India, and leave them, as they ought to be, the masters of the position. Only that morning they received information of another interruption, but he believed that was caused by the repairing-ship, and would soon be set right. The new cable would cost something like £110,000. A good deal had been said about the interruptions, and it had been urged in Queensland that it was important that a competing cable should be laid down so as to reduce what they termed the very exorbitant rates of this company. He could only say that the company had done everything they possibly could to meet the requirements of Queensland, but it seemed to him that there was nothing that would satisfy the Queensland Government. He wished publicly to say that when Queensland came forward and said she was in earnest in wanting to do something to reduce the rates, the company would only be too glad to negotiate with her. If she would guarantee the company the modest dividend they were paying now, they might to-morrow reduce the rates to anything she pleased, even to 2s., but up to now she had declined to take any part whatever with the other colonial Governments in the way of reducing rates. What she was prepared to do was to join with the other colonies in laying a competing cable in the Pacific, but the company was on good terms with the other colonies, and they were not prepared to take action with Queensland in anything that would be detrimental to the interests of the company. He hoped this would be made known in Queensland, and he wanted to tell the Queensland Ministers that they were a good deal more indebted to the company for the progress of the past few years than to their own internal Government. When the new cable was laid he considered that their position would be invulnerable.

The report was adopted without discussion, and the meeting closed with a vote of thanks to the chairman.

The Anglo-American Brush Electric Light Corporation, Limited.

The following circular has been issued to the shareholders of the Corporation:—

In compliance with the request of several shareholders, and in view of many important events during the last few months, the directors, while not anticipating the approaching annual report, consider that a brief statement as to the present position of the corporation as regards prominent questions may be of interest. By the Electric Lighting Amendment Act, which received the Royal Assent on 28th June, 1888, the chief obstacles to the investment of capital in central lighting stations have been removed. Although the alteration of the law does not meet all wishes, nevertheless the extension from 21 to 42 years of the period after which the local authorities can require the undertakers to sell, and the improvement in the terms of purchase which the Act effects will be of material benefit to the industry. There are, indeed, good grounds for hoping that the recent amendment of the Act of 1882 will prove a turning point in the history of the industry, and there are already many indications that the long anticipated revival in the electric lighting business is now at hand. Among the electric lighting companies which have already been formed for the supply of electricity may be mentioned the Chelsea Electricity Company, in which the corporation is interested as contracting for the generating plant. This company, which has been established for the purpose of supplying electricity to one of the most important residential districts of London, possesses a Provisional Order which secures to the company the benefit of the new Act. It proposes to put down plant in the first instance sufficient to supply 6,000 lights. The system of distribution which is being adopted is one in the economy and efficiency of which the directors have the fullest confidence. The electricity generated at the central station will be conveyed by underground mains to sub-centres where accumulators, which the Electrical Power Storage Company is supplying, will be charged. From these storage stations the current will be distributed to the surrounding buildings. The corporation has also made arrangements for establishing central stations at Bournemouth and other places. The negotiations with the Commissioners of Sewers with a view to the electric lighting of a part of the city of London have been resumed, and the corporation having submitted to the commissioners proposals which will meet the objections made by some of the members of the commission to the former scheme, there is every reason to hope for a satisfactory issue. The volume of the corporation's business during the year shows a very considerable increase as compared with the corresponding period of previous years, and the factories are at present fully employed Among the more important and remunerative work that has been done may be mentioned the contracts in connection with the Glasgow, Barcelona and Melbourne exhibitions. At the Melbourne exhibition the Australasian Electric Light and Power Company has installed, besides a large Victoria incandescence plant, about 40 Brush arc dynamos and 1,000 arc lamps. The whole of this plant was supplied by the corporation and shipped within a period of two months, and is now in very satisfactory operation in the antipodes as the largest temporary installation on record. The continental business of the corporation is also developing very satisfactorily. The factory at Vienna is now a source of revenue, and at Temesvar, where the lighting has hitherto been confined to the streets, the corporation is putting down extensive plant, with a view to supplying the light to private consumers. The theatre and other buildings are already supplied, and the demand for the electric light has very largely increased. In July last the directors had reason to congratulate the shareholders on the decision of Mr. Justice Kay in the action brought by the Edison and Swan United Electric Light Company, by which judgment was given in favour of the corporation upon the main issue, viz.: the Edison patent, and in favour of the Edison-Swan Company upon the minor issue of the Cheesbrough patent. The well-known "Victoria" incandescence lamp, which is manufactured by the corporation, is absolutely independent of patents other than those held by this corporation, and is superior to any in the market, either in this country or abroad, in cheapness, durability and efficiency. In order to cope with the increasing demand, a new factory for the manufacture of these lamps upon a very large scale is being fitted up in the neighbourhood of London. The ditectors feel they are able to congratulate the shareholders upon the improved prospects of the electrical industry generally, and having regard to the fact that during the past few years of comparative stagnation the efforts of the corporation have been directed to developing its resources for undertaking large contracts, it is now in a very favourable position for profiting by the revival which is at hand.

By order of the Board,
E. GARCKE, *Manager and Secretary.*

112, Belvedere Road, Lambeth,
3rd October, 1888.

Brazilian Submarine Telegraph Company, Limited.—The accounts of this company, subject to audit, show a profit sufficient to enable the directors to recommend a final dividend of 3s. per share, making, with previous distributions, a total dividend of 6 per cent. for the year ended 30th June, 1888, and also the payment of a bonus of 2s. per share, both free of income tax, which together will amount to £32,500, being a distribution, in the aggregate, of 7 per cent. for the past year, leaving a balance of £34,539 3s. 7d., of which amount £30,000 has been placed to the reserve fund, increasing that fund to £170,175 11s. 5d., and £4,539 3s. 7d. carried forward. The above dividend and bonus will be payable on the 31st inst.

The Globe Telegraph and Trust Company, Limited.—The directors have declared an interim dividend of 3s. per share on the preference shares, less income tax, and of 1s. per share on the ordinary shares, free of income tax, for the quarter ending October 18th, payable on and after that date.

TRAFFIC RECEIPTS.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending October 5th, 1888, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £4,359.

The Eastern Extension, Australasia and China Telegraph Company, Limited. The receipts for the month of September, 1888, amounted to £41,095, compared with £36,400 in the corresponding period of 1887.

The Great Northern Telegraph Company, Limited. The receipts for September, 1888, £23,400: January 1st to 30th September, 1888, £202,600; corresponding months 1887, £197,720; and of 1886, £195,860.

The Brazilian Submarine Telegraph Company, Limited. The traffic receipts for the week ending October 5th amounted to £5,216.

LIGHTNING CONDUCTORS.

(*Concluded from page* 377.)

SIR JAMES DOUGLAS said: The few remarks I have to make upon this matter are in relation to experience with a large number of conductors in exposed stations now extending over about 40 years. I may say that my experience is comforting to the committee. It has been with lighthouse towers, and there we have been following out for nearly the last 50 years the advice of Faraday entirely. For protecting a lighthouse Faraday advised us to start with the base of the *metallic lantern*. The conductors are an inch and a-half by three-quarters half round—that is to say, the half, of an inch and a half copper bar. They are carried down the interior of the tower on the internal surface of the wall, with branches to all metal work. I think much of this was given in the report of the committee, but perhaps there is no harm in repeating it. The earth is obtained by a copper plate, 2 feet 6 inches square and $\frac{1}{8}$ inch thick, buried at a distance of 15 feet from the tower, and about 12 feet below the surface of the ground, generally securing damp contact. At exposed stations at sea the bar is carried down to about 8 feet or 10 feet below low water spring tides, so as to be always immersed in the waves. I may say that during 40 years, perhaps seven or eight accidents have occurred, but no accidents of a serious nature, and in all cases when an accident has occurred we have been able to discover that it was due to a defect in the conductor. Generally it has been found to be due to a mechanic, who has been working at the station, and having disconnected the conductor, has not properly reconnected it. Therefore, these are points that we feel confident are to be got over by more rigid inspection. More rigid inspection is now being carried out, and I for one feel that I should be perfectly safe in any tower where this system is carried out, and where the conductors are properly looked after. Having the conductors carried down the interior of the building we have every opportunity of examining them, and I rarely visit a lighthouse without inspecting every communication up and down, and generally testing the conductor with a common linesman's instrument from top to bottom. There is one practical point on the question of iron *versus* copper, and it is this: the rapid corrosion of iron, compared with copper. It is quite possible with an iron conductor in an exposed station we might visit that station after an absence of seven or eight years and find very little of the conductor left. I have known bars of iron corrode at a very rapid rate in this country, and of course corrosion is much more rapid in hotter climates. One point I have omitted to mention which will be comforting to Mr. Preece, that during 40 years where those conductors have been carried out on towers surrounded by dwellings, in only one case has an accident occurred to the dwellings, and then it was due to the imperfection of the conductor in the tower. It was not a case of the dwelling being struck from the outside.

MR. SYDNEY WALKER said: Speaking as a practical engineer, I would remind the meeting that it is the engineer who will have to carry out the work, and he will get the blame if anything goes wrong. I may mention one instance of a chimney being destroyed at a colliery in Derbyshire. The proprietors said it was cheaper for them to have the chimney destroyed than to fix a lightning conductor, because the destruction of the chimney occurred so seldom. In the face of that it would be a very uphill battle to fight to induce people to take up lightning conductors, and therefore I would only too gladly welcome anything which would lessen their cost. I consider that the statements made by Mr. Preece in his address as President of section G, after the experience and study of a great many years, were absolutely correct. If we have a conductor properly constructed, properly fixed, properly pointed, properly earthed, and properly inspected, the building it is attached to is absolutely protected. I do not think there is any instance of any building having been damaged where the whole of these conditions have been complied with. I think the cases where destruction or damage has occurred have been where some of the conditions have been neglected; for instance, where the conductor was leaded into a tombstone, and I do not consider a tombstone good earth. It appears that the problem we have to solve is exactly similar to the problem involved where the embankment of a huge reservoir of water placed for the benefit of a town is very liable to give way. If the water is allowed to come down its own way, it brings destruction in its path; if it can be carried off harmlessly into another channel or into the deep bed of the river, the town will be saved. But there is this difference in the case of water—there is only one path to provide. Water has to come down, and there is an end of it; but in the case of lightning we have a double path to find. The lightning flash has to come from the cloud to the ground, and to get back from the ground to the cloud; and that is a point which, I think, we are rather overlooking. It is here that the importance of a good earth becomes so apparent. If the conductor ends in a tombstone the return path is represented by the air space between the line of the conductor itself, any moisture that may be on the tombstone, and any portion of ground that this moisture brings into connection with the conductor and the cloud. Whereas, if a good earth be obtained, say such as gas or water mains, spreading out into the surrounding earth perhaps for miles, and in more or less good conductive connection with it, the return path is represented by the air space between this large surface of ground and the cloud; so that its electrical resistance will be very small indeed, compared with that offered where a bad earth rules. And this has a most important bearing upon the question of side flash, since if the resistance of the conductor and of the return path are both very small, the whole of the work will be done in passing from the cloud to the conductor, so that there would be no appreciable voltage between any portion of the conductor and, say, a gas bracket, just as with electric lighting mains in parallel the voltage between one terminal of an incandescent lamp and the same side of the dynamo is usually very small indeed. If, however, the resistance of the return path be large, say equal to that of the outgoing path, as it may be if the earth is bad, then at any point in the conductor you may still have half the voltage of the cloud left, and should a gas bracket in fairly good connection with the mass of gas mains be within a certain distance of the conductor, this will open the very path it was requiring, and it cannot help sparking into it, just as if, in place of bridging a pair of electric lighting mains whose difference of potentials was 100 volts by a lamp of 100 volts, it is bridged by two such lamps in series, there will exist between the junction of the lamps and either main, or either side of the dynamo, half the total voltage, so that a 50-volt lamp connected to that junction and either main must light up. With regard to the question of iron and copper, I am of opinion that electrically it does not matter which is used, as the resistance of the conductor, whichever metal it is composed of, should form only a small part of the total resistance of the circuit; but for durability copper is decidedly to be preferred. As Sir James Douglas remarked, iron will not stand the weather, and I would also point out that iron will not stand the chemical action of the fumes issuing from the chimneys of iron and chemical and other works. I would like also to call attention to another point, though I do so with considerable diffidence. Dr. Lodge has stated that "Ohm's law is not in it." I venture to think that Ohm's law *is* in it, if you call things by their right names. I suggest that "impedance," "self-induction," and "electro-magnetic inertia" are merely our old friend "back electromotive force." If you split a rod into a number of filaments in the way Dr. Lodge has suggested, and imagine that a current passes in each, each creating its own magnetic field around it, which gives rise to an opposing E.M.F. in all the other filaments, then the algebraical sum of all these opposing E.M.Fs. gives rise to the apparent increased resistance, which has to be provided for, just as the back E.M.F. of an electro-motor has. I will only mention one other matter. Unfortunately, loss of life and property by lightning is not confined to buildings. It is well known that cattle and human beings are often struck in the open, for no apparent reason, and there have even been cases where animals have been struck when grazing in a valley, though the surrounding hills were untouched. I would suggest that this is due to electrical currents within the earth's crust, possibly in some cases induced by the motion of the cloud itself, the difference in conductivity of the different strata causing a kind of selection to take place, the result being that, notwithstanding the fact of the cloud being farther from the bottom of the valley than the surrounding hills, the increased difference of potentials, combined with the difference in conductivity, make the path by the valley the one selected, rather than that by the hills.

Mr. **Brown**, of Belfast: If one were to use a revolving camera any flashes passing consecutively over the same path would be separated on the plate, and it would be easy to calculate the time interval between them from the rate at which the camera was revolving. I have used a revolving camera myself for the purpose of registering, and I am sure it would be quite easy to determine an interval of less than the thousandth of a second. In order to investigate the other question, as to the time interval between the streams of flashes as they appear on the photographs shown, that could easily be done by setting up one stationary camera to photograph the thing in the ordinary way, having a second camera revolving on a vertical axis.

Mr. G. J. **Symons**, F.R.S., said: I ought, perhaps, to offer some apology for speaking on this subject, but it is one to which I have devoted much of my attention for considerably over thirty years. In fact, as far back as the Aberdeen meeting in 1859 I was one who took part in a discussion upon lightning conductors—at which Sir William Thomson made, as probably he will remember, the very remark which has been repeated to-day, that when he suggested to the Glasgow manufacturers to set up lightning conductors they all said it would be "cheaper to insure." Lord Rayleigh has said that it is desirable to get the evidence of practical men. I have nothing to do with the construction or erection of lightning conductors, but all through my life it has been my hobby to investigate every accident that I can of damage by lightning, and in that way I have got experience which is possibly of some value. Then eventually, when the Lightning Rod Conference was formed, I was one of the delegates, and they did me the honour of making me secretary, consequently I had a great deal of evidence brought before me; and I must say that the impression left upon my mind, as the result of the whole of my experience, is precisely in accordance with that of Sir James Douglas, namely, that, as far as I can judge, if people will only put up conductors precisely in accordance with the rules, and fulfil all the conditions, those conductors are absolutely safe. I have not a shadow of hesitation in saying so. I admit that accidents have happened now and then to buildings which have had conductors, but a reasonable explanation of every one of those accidents, to the best of my knowledge, was forthcoming; and you all know how very much easier it is to produce destructive criticism than to construct a system. Prof. Lodge's experiments (and I yield to no one in appreciation of Prof.

Lodge as an experimenter), were, after all, simply laboratory experiments, and it seems to me that what we want is something on an infinitely larger scale. I am not going to suggest how we can make artificial lightning, so that we may deal with the actual thing itself, although the idea has often occurred to me that a great deal of information upon the subject could be obtained if upon the summit of some of those hills which are most frequently struck a series of interrupted conductors was put up where the lightning would presumably strike, on a series of tall masts; without risk to human life, we might learn a good deal more than we know at the present time. I certainly do feel most desirous, on the one hand, that if possible lightning conductors should be cheapened and rendered more generally accessible; but, on the other hand, that we should not simply, on the strength, as I said before, of those laboratory experiments, allow it to go forth from this great Association that there is any uncertainty in the protection of the public buildings throughout the country. It seems to me that a very serious responsibility attaches to those who would make a suggestion of that nature. We have the experience, not only of this country, but, as M. de Fonvielle has said, of France; we have that of Germany, and that of Austria, and we have also the experience of the United States on an enormous scale. Tens of thousands of lightning conductors are erected, and millions stirling have been invested in their erection; and I must say that it would be with considerable regret that I should hear it go forth from this room, simply on the strength of some laboratory experiments, that all that has been done is to be regarded as almost worse than useless. The discussion has already gone on so long that I should be sorry to enter into many points upon which I have made notes, but there are two or three upon which I should certainly like very briefly to say two or three words. I have forgotten who it was, but one of the speakers made, I think, very justifiable allusion to the extraordinary story about ball lightning rubbing against his trousers, but as to the existence of ball lightning or some phenomenon of slow lightning, I have heard of it from so many persons in all parts of the country, and in all countries of the globe, that I cannot dispute its existence. As for understanding it, I do not. I remember quite well the experiments that were made (I am not electrician enough to say whether they were correct or not) at one of the meetings of the Society of Telegraph-Engineers by Mr. Varley, in which he actually produced something closely analogous to the phenomenon of ball lightning.* Then with respect to iron conductors, first of all there is, as Sir James Douglas said, the question of oxidation. I may be told, "Oh, it can be galvanised;" but I know enough of galvanised iron to know that it is not an everlasting material by any means. Then another thing, as has been well pointed out, is that the gases coming out from many of our factories are seriously injurious. With respect to the area of protection, I know that I am within the mark in saying that hundreds of cases have been investigated, and that there were not, as regards the area of protection laid down in the report of the Lightning Rod Conference, more than two instances, and those were a little doubtful, in which anything had been struck within that area of protection. The attacks all round are alarming. It is suggested that lightning could not be trusted to go down a thick copper rod, and that there is no such thing as a protected area. One would be afraid to go to church in a thunderstorm because the conductor on the top of the church would not protect them. Up to the present time there has not been a single case of a church having been struck which was provided with a good and efficient conductor. Churches are struck every year, because they either have no conductor or a bad one. Sometimes, as one of our friends said, the bottom of the conductor is let into a paving stone. At one of the cathedrals the conductor was led into a pickle bottle. Of course it is a great stupidity to allow a country blacksmith to put up conductors in that manner. There is no record of the failure of a properly made and erected lightning conductor. Mr. Preece, in spite of all his attention (and he did work thoroughly hard upon this report), has not remembered all the details as to the upper terminal. The report suggested that what was called the upper terminal, that was the extreme top, should consist of a blunt point surrounded at about 6 inches below the top by a small ring from which very sharp needle points should project. The idea of the delegates in designing that upper terminal was (I am afraid I do not use proper electrical language, because I am not an electrician), that the acute points, the very sharp needle points down below, were to disperse the electricity, and act as a preventive; but if a disruptive discharge occurred, if the cloud came up so rapidly that the points could not get the potential down fast enough, and a disruptive discharge came upon the conductor, the absolute top of the conductor was there to receive it. The object of the blunt point was this: that if lightning fell upon a sharp point, it invariably heated it, and there are cases on record of the fused metal of the upper terminal igniting buildings. With respect to the proposed use of small wires I feel quite aghast, for this reason, that I have been in dozens of houses which have been struck by lightning, and almost the first thing that is found is that the bells go wrong. The fact is this, that the lightning as a rule gets into the bell wires; it disperses them in dust as a brown mark all round the walls of the room, and every wire is gone. If the old-fashioned conductors, which are as thick as my finger, are to be replaced by something analogous to bell wires, I wonder what is to happen after the first flash.

Mr. **WALKER**, sen., said: The last speaker has expressed a hope that experiments will be made by means of conductors elevated on a hill. I happened myself to have been in such a case. Three or four years ago I read a paper before the Royal Meteorological Society, on an obelisk being struck. I happened to be half a mile from it, and I am rather inclined to think, from my experience of what then took place, that there are some storms in which no amount of precaution you can take will prevent destruction. The whole of the air on the occasion was an entire environment of light; there was no flash, and although I was half a mile from it, I could see that the obelisk was the only thing that was struck. It broke off at the top; the lightning came out in 14 different places, and it ran out in one case to 100 feet, and broke off some rock before it went down and ploughed up the ground in grooves. The theory was simply a theory that the lightning did not come down from the cloud but that it went up from the earth to the sky. Nothing has been said in this meeting to that effect. I would like very much to see what could be done to protect the obelisk. It has been twice struck, and there is some discussion as to what shall be done in building it up again.

Mr. **PREECE** asked if there was a lightning conductor.

Mr. **WALKER**: There was no lightning conductor upon it. We want this Association to tell us what to do to prevent these things in future.

Mr. **TRUEMAN WOOD**, referring to one of the photographs, said the so-called dark flash, whatever it was, certainly was not the result of over-exposure, as had been suggested, because the white flash, which was presumably on that theory less exposed, over-rode the black one, whereas, of course if the black part was the part of the plate which had received the most exposure, the black one would show over the white one. In a second photograph there was an exactly similar dark line which was evidently the result of *halation* or reflection from the back of the plate, and therefore he thought there could not be much doubt that the dark flash was really the result of *halation* or reflection from one of the other flashes.

The **PRESIDENT** then called upon Lord Rayleigh, Prof. Lodge and Mr. Preece to reply to the discussion.

Lord **RAYLEIGH** said: I remember a suggestion that

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* See Proc. Roy. Soc., Vol. XIX. (1870-71), pp. 236—242.

Prof. Stokes once made, which I do not think has ever appeared in print. I am not quite sure whether I ought now to mention it, but I am encouraged by Sir William Thomson to do so. I think there was no doubt, as Mr. Wood has said, that the appearance of the black flash does not suggest that over-exposure is the explanation. Prof. Stokes's view was this: he thought that under the influence of a flash the atmospheric gases of oxygen and nitrogen were combined so as to produce considerable quantities of the oxides of nitrogen; that those oxides of nitrogen, formed along the line of the flash, were opaque to the invisible rays at the upper limit of the spectrum, to which most photographic action was due; and that this, when another flash occurred, illuminating the background of the cloud, would darken the place where the first flash had been; the mark of the flash would appear as a black line on account of its opacity to the general first light of the background.

Prof. OLIVER LODGE said: So many things have been remarked, and so much might be said on points which have not been commented upon, that one must exercise selection in what one mentions. I would first say a few words suggested by the remarks of the various speakers. Mr. Walker, Mr. Symons, and Mr. Preece, too, spoke as if I have especially attacked the report of the Lightning Rod Conference. But that I have not done at all; I have made great use of the report, and I think that conference has done a very valuable piece of work. They have collected together all manner of details of destructions and of failures of lightning rods. The whole of the report is bristling with failures of lightning rods, so that I am at a loss to understand—no, I do understand—how they can say that rods never fail. They say that a "properly" constructed lightning rod never fails, because whenever a thing fails they always say there was something the matter with it. They generally say bad earth, but why a thing ought to have such extraordinarily good earth I never could tell. What is the difference between one end of the conductor and the other? You stick three points at *that* end, and you want a lot of roots at *this* end; suppose it is up-ended, why not have the roots in the sky and the points down below? Why should one end have to be treated so carefully and the other end be left to itself? So far as protection is concerned the points at the top and the three points at the bottom ought to do equally well. Of course, it may be inconvenient to have the ground ploughed up and things of that sort. You may have the ground and the water pipes broken if you have not good earth. We ought therefore to have a good deep earth; but even if we have no earth flashes ought not to spit off from the conductor to such things as safes and gun-barrels, and rain-water gutters. It does that because it meets with obstruction—impedance, I do not care what you call it—a spurious resistance. You may use the word resistance if you like, but it is not what we ordinarily call resistance, it is like inertia. It is like having to move a great freely-suspended weight; there is no resistance to its motion; you knock it with a hammer and expect it to fly to the other end of the room, but it scarcely moves. You may knock the hammer to pieces; you may do a great deal of damage, but you cannot move the weight suddenly. That is the kind of obstruction that is met with in a lightning conductor. As regards failures of properly-constructed lightning conductors, I want to know from Mr. Symons — there will be plenty of opportunities for continuing this discussion in print—why the Hotel de Ville at Brussels was set on fire by a lightning flash, because if anything was well protected, and even admirably and thoroughly protected according to orthodox principles, that building was so. I myself thought it was protected. When I say that a building is not completely safe, I do not mean, and have never thought of meaning, that lightning protectors are of no use; they are of very much use, but they may occasionally, and I believe do occasionally fail. M. de Fonvielle referred to the great experience that Mr. Preece has had, and also to the experience gained in France of all sorts of conductors, telegraph posts, and things like that. It is true they do not fail much, but then a telegraph post, and an obelisk, and a lighthouse are the easiest possible things to protect. There is just one column, and if you stick one conductor down, there is not much chance of its spitting, or its doing much damage, or anything else. In the case of the Monument, in London, I believe that the handrail of the staircase is the lightning conductor. I do not know how it would feel if it was struck; I dare say it has been struck, probably in the night when nobody was there; but it has never been damaged in the least. It is not so easy to protect powder magazines, or houses where there is escaping gas. If the lightning flash is only a little bit away from a leaden gas pipe, it will very likely fuse it and light the gas, and you will have the house burnt down. You may not know that it has been struck, but you will wake up in the morning and find yourselves burnt. Prof. Forbes has asked me to say why I do not use one pair of knobs instead of two pairs of knobs to try the experiment. If Prof. Forbes tried it with one pair of knobs he will find that he cannot do it at all. There must be two pairs of knobs somewhere. *Here* [illustrating] are the two knobs of the Holtz machine, and *here* the alternative path. How are we to get sparks between these knobs? If we were to put an alternative path to an air-space we must have another air space somewhere to enable us to do it, but it need not be done exactly as I have done it. I will not go further into that point now, as the discussion can be continued in print, but I may put my views briefly thus:

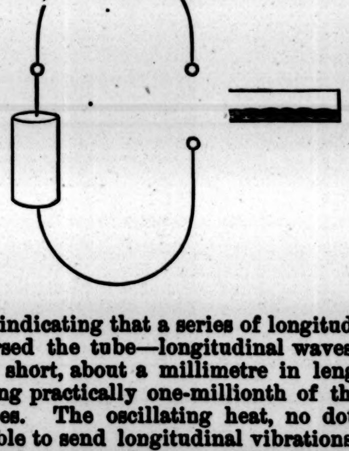
These discharges are oscillating currents of extraordinarily great frequency—something like a million a second. For these currents it is only the outer surface of a rod that conducts, therefore its obstruction is due to the space surrounding the conductor, and it is not due to the material of the conductor. It is only the outside tube of the conductor that conveys any current, and therefore the conductor, whether iron or copper, does not get magnetised at all. It does not matter about its permeability, or about its conductivity much. The current is very great; even from an ordinary Leyden jar the current produced when discharged through an ordinary tongs is about 3,000 ampères. The current in a lightning flash is, no doubt, enormous—I think a million ampères for the time it lasts. That it is very great was shown by the heating powers and the destructive powers it has, though its duration is so extremely small; and hence it is that the impedance being also very great, we have this large amount of ohms and the tremendous current, and so we get a tremendous difference of potential at the end and the liability to spit off.

Seing that only the outer surface conducts, what is the good of the inside of the rod? It may be able to conduct some heat away and so prevent melting, or it may not have time to do that. Probably there is no very great good in it, but if we are going to have a tube we had better have it spread out flat. Or, better still, have a strand of separated wires, or have a series of wires about the size of telegraph wires. Mr. Preece knows very well that the iron wire conductors on the telegraph posts protects them, and a house would be protected in a similar way, and cheaply, by putting a great number of common galvanised iron telegraph wires up. That is my view; but it is not authoritative. If what I said would be authoritative, and would go forth as a statement from this room, of course I would hold my tongue; but, as it is, I simply say that which I think true at this time. It is found that all the failures in the case of lightning conductors are due to the spitting off from them; are due to this high potential; are due to the impedance of it, the obstruction of it, to the fact that it does not conduct easily away as you would expect it to do; not due to the melting of it. Mr. Symons, in his report of the Lightning Rod Conference, gave, in an appendix K, a list of conductors which had been melted by the flash, and he apologised for the shortness of the list. No apology was necessary; the list was short because they very seldom get melted. If you analyse those which Mr.

Symons gave you will find in every case but one that it was only the upper terminals which had been melted, not the full length of the conductor. There is only one case of complete destruction, and that was a bell wire, and even so it exerted a protective influence. So then we learn that when they are bell wires they are melted; but I do not want the wires which are to be put up to be of the thinness of bell wires.

Iron buildings, as Sir William Thomson said, are practically safe for powder magazines, and the safest things you can make, but even with them some little care is wanted; the iron must be in absolutely good connection all through. If there is a gap left anywhere there may be a spark in that gap. When an iron building is struck you will have the thing surging about in all directions, and you might get sparks in the most unexpected places, and for the most apparently ridiculous reason. It might be only half an inch long or a quarter of an inch long—that would be quite sufficient to light gas and do all the damage. There is in houses the danger of gas, and there is danger in powder magazines—not from sparks a yard long, those might be guarded against—but let there be a gap of a quarter of an inch, and you may get the sparks where you least expect them.

As regards the possible effect of sound waves—sound waves produced by these sparks—may I just call attention to one little experiment which is not my own, but which was first made by Dr. Guthrie? It has been called attention to at the Physical Society afresh and independently by Dr. Cook. There was a discharging Leyden jar which, as I have often said, gives ether waves of a calculable length. Well, if a plate of fine powder is put near its spark, it gets thrown into ripples. This modification of the experiment has been made by Mr. Chattock; he took a little tube, like a resonant tube, and sprinkled powder in it; when the spark occurs near the mouth of that tube there are ripples on the sand indicating that a series of longitudinal waves has traversed the tube—longitudinal waves which are extremely short, about a millimetre in length: sound waves being practically one-millionth of the length of light waves. The oscillating heat, no doubt, of the spark is able to send longitudinal vibrations down the tube—sound waves about a millimetre long, which throws the sand into ripples. It might be those longitudinal sound waves which Sir William Thomson mentioned, and which might in some way precipitate a discharge in the neighbourhood; but no doubt there are other causes.



Mr. **PREECE** said: I introduced at the commencement of my remarks an unfortunate allusion. I compared Prof. Lodge to our old friend Balaam, and I said that there were three persons, or three quantities, mixed up in that transaction—Balak, Balaam, and the donkey; but there was a fourth. Now, there are a good many errors of translation in our Scriptures, and I am strongly inclined to think that the word "ass" should have been translated "phonograph." What really communicated with Balaam was a voice, and that voice was right. Balaam had made a mistake, as Prof. Lodge has made a mistake. The voice came directly from Heaven, and it is with the voice that I claim relationship. There is very little for me to say. Prof. George Forbes has put my view of the question of mathematicians *v.* practical men very much on the right footing. It would be folly and absurdity on my part to call into question for one moment the conclusions of our masters in mathematics. We are all students who lie at the feet of our Gamaliel, Lord Rayleigh. Everything Lord Rayleigh writes, everything he says, and everything he does, is studied with the very greatest care, and I should be very grieved if anybody left this room and thought that I have called into question anything that masters like Lord Rayleigh and Sir William Thomson, or Prof. Rowlands, have ever said. As regards Sir William Thomson, he is one of ourselves. He is not a physicist—he may know a little about it; he is not a mathematician—he may know a little about that; but what he is is an electrical engineer; he is the head of the profession, he is the first electrical engineer in the world. There is no doubt that we all made mistakes, engineers and mathematicians as well. What I meant to imply was this, that in the present day, what with technical institutes, what with the innumerable students that are sent into the world, especially into the electrical world, every year, we find some of those young fellows coming out with a smattering of mathematics; they write papers for the technical journals, and they thrust upon the electrical world conditions and conclusions arrived at by their mathematics with a coolness and an effrontery that are simply appalling. It is to try and check that sort of thing, which is growing to a very serious extent, that I made the few remarks I did about the necessity of being excessively cautious in acting upon any conclusion that might be derived from mathematical development, unless (and mind, I have always put in this), confirmed by actual experience. The true mathematician will never come to a conclusion, and never thrust his conclusion upon the world, unless he is sure of his ground, but the imperfectly trained gentlemen are too fond of throwing out conclusions, without the least confirmation by experiment or anything else. I will not occupy your time any more, because there will be other occasions when the points of difference between us can be argued. I may say that they have dwindled down to a very small thing indeed. As regards the question of iron and copper, in answer to Sir William Thomson, I would say that most—in fact, all—of those lightning conductors of which I have actual experience are of iron, and always have been, as most of you know who have read the reports I have written. I am a great advocate of iron. I think the use of copper to the extent that it is used introduces a needless expense into the erection of lightning conductors. My own impression is that every private house can be thoroughly protected, according to the recommendations of the Lightning Rod Conference, for at least a pound. Anybody can buy a coil of stranded iron rope, and if you take an iron rod about a quarter of an inch in diameter with the finial Mr. Symons has referred to, I believe that we can safely protect our houses with lightning protectors for a few shillings, instead of now, where copper is employed, indulging in the expenditure of a few pounds.

The **PRESIDENT**: I am sure we have all heard with very great pleasure the discussion that has taken place, and it is with very great diffidence indeed that I feel called upon by my position, rather than by any desire to do it, to say a few words in summing up what seems to me to be more or less the result of the considerations that we have come to. I am glad to say that I have had no experience of lightning. It is not an agreeable thing to have anything to do with. However, it is most closely allied, there is no doubt about it, to static electricity, which I have heretofore looked upon as one of the most beautiful of the vast forces of nature; and I hope now that our experiments in what has been hitherto called static electricity will gain fresh interest from the practical applications that are likely to be derived from it. I think, as far as Prof. Lodge's position is concerned, it is very important to observe that there are a number of experiments that have taken place, especially in connection with some tramway lines, with telegraph instruments and with telephones, with effects that have taken place at terminal stations at considerable distances from the lightning, which require to be investigated, and about which we know very little, and which have not been considered very much.

Mr. Preece: I meant to point out what Prof. Fitzgerald is now saying, that we have experienced sparks in our telephone exchanges and in our electric light installations where there is a mere metallic circuit. What Prof. Fitzgerald now refers to is the practice exactly, and it is a most interesting point.

The President: We are all very much obliged to Prof. Lodge for his experiments, because heretofore, I think, there has been little or no experimental observation of this particular point, and it is a very important thing to see, especially if telephones are likely to become of very great use on a large scale, that during thunderstorms, if we can possibly do it, we should protect people from injurious effects owing to the presence of a thunderstorm, perhaps at a considerable distance from the person that was observing it. It is very analogous, it seems to me, to Prof. Lodge's experiments, and they were very much to the point in that explanation; but I am inclined to think that the experiment that he has performed was not exactly analogous, and in many ways was not at all analogous to a lightning flash. Mr. Preece has called attention to the fact that a lightning flash is very much more like a discharge between the plates of a condenser, much more like the breaking down in the insulation in a Leyden jar when it bursts through the glass. Prof. Lodge's experiments have not been on the effect of putting a point upon one of the plates of an air condenser, and if he does make some experiments on it, I think he will find there will be a considerable diminution in the amount of sparks.

Prof. Lodge: If you read my paper you will find those experiments done, too.

The President: I am afraid I have not studied the thing completely; but the experiments that have been alluded to to-day were not exactly analogous.

Prof. Lodge: No.

The President: It would have been well if we had been told of experiments which were exactly analogous. There is a question with respect to the alternation of currents. I would call Mr. Preece's attention to this, that even though there might not be millions of alternations per second, a great many of the effects of an alternating current would be produced by an extremely sudden current of very short duration—that the effects that have been observed were due to the very sudden change in the strength of the current. Now, the effects of a very sudden change in the strength of the current can be produced by a single spark, whether there is an alternation or not. So that a great number of the effects that Prof. Lodge has observed, and in reference to which he seems to think it is necessary to have an alternation several million times a second, would be produced by a single sudden discharge of a millionth of a second.

Prof. Lodge: Not quantitatively.

The President: It might not be an exactly similar case with all of them, but a great number of the effects would be produced; and I think a great number of effects, similar to those that Prof. Hertz has observed, would occur, where at a distance from a spark he has observed electro-magnetic effects. That might also cause electro-magnetic effects in the inside of the house due to a spark of electricity going to the outside of the house. I would like to make one more remark. Globular lightning would possibly be due to the dissociation of molecules of the air, and to there being a region of the air in which there are atoms going about by themselves, and combining amongst themselves and producing an illuminating part of the air, the original dissociation of the atoms having been produced by some electrical effect. I am not sure that it is worth considering, but it is a thing that is possible, I think. In conclusion, I think the principal thing for us to pay attention to is that prevention is better than cure, and as M. de Fonvielle has called our attention to it, there is very little doubt but that the presence of a considerable number of lightning conductors unquestionably affords a great deal of protection to the area within which they exist. As he remarked, in the city of Paris they hardly ever have any accidents from lightning, and it has been observed on a larger scale that the existence of lightning conductors actually, as a matter of fact, produces a discharge which, to a great extent, probably neutralises the clouds, and thereby prevents the lightning flash occurring at all; so that it is very desirable that, if possible, the whole country should be covered with lightning conductors, and that we might have as many points as possible, and thus, as far as we can, prevent the occurrence of lightning. There is no doubt that when a flash occurs it is extremely disagreeable, and we had better adopt the old rule that "Absence of body is better than presence of mind," and avoid being near it if we can. That leads me to the point that Prof. Lodge has mentioned, which reminds me of the effects you get in a room, when each person wishes his neighbour to open the window in order that the draught might be upon his neighbour and not upon himself. Mr. Preece, I think, would suggest that everybody in his neighbourhood should put up lightning conductors, and that he should not have a lightning conductor, in order that he should be protected by other people's lightning conductors. That would be a very pleasant arrangement, but I am afraid we cannot have that exactly, and that the next best thing is for us to have as large a number of lightning conductors as possible, because I do not think there is any doubt at all, quite independently of any experiments of Prof. Lodge's, as far as I can see, that as a matter of experience lightning conductors have protected buildings whatever the explanation of it is, and that there is no doubt but that we have been right on the whole. Perhaps there are improvements possible; perhaps we may be able to protect ourselves from those unfortunate discharges that occur in telephones and so forth; but as a whole lightning conductors have been a great protection to mankind from danger from lightning. That is undoubtedly the result of our experiences.

NEW PATENTS—1888.

8170a. "Electric shunting device." H. J. Allison. (Communicated by the Baxter Electric Manufacturing and Motor Company (Incorporated), United States). Dated June 5. (*Complete.*)

13954. "An improved portable electric light apparatus." S. Charlesworth and J. P. Hall. Dated September 28.

13964. "Improvements in the application of portable electrical batteries and incandescent lighting to articles of wearing apparel and other analogous purposes." M. McMullin. Dated September 28.

13984. "Improvements in electric accumulators." B. J. B. Mills. (Communicated by J. Barbier, France.) Dated September 28. (*Complete.*)

13987. "Improvement in electric lighting." L. Saunderson. Dated September 28.

13994. "Improvements in and relating to cut-out or safety devices for electric circuits." J. Kendall and O. Cooper. Dated September 28.

14030. "An improved apparatus for generating, graduating the strength of, and distributing electro-magnetic currents for medical and curative applications." T. B. Grant. Dated September 29.

14090. "An improvement in combination with electric light switches for securing better contact." H. C. Harold and R. Jenkins. Dated October 1.

14095. "Improvements in and connected with dynamo-electric machines and electric motors." J. Swinburne. Dated October 1.

14110. "Improvements in telephone central station apparatus." T. N. Vail and J. A. Seely. Dated October 1. (*Complete.*) [Date applied for under Section 103 of the Patents, &c., Act, 1883, March 1, 1888.]

14111. "Improvements in telephone exchange signalling apparatus." T. N. Vail and J. A. Seely. Dated October 1. (*Complete.*) [Date applied for under Section 103 of the Patents, &c., Act, 1883, March 1, 1888.]

14129. "Improvements in and relating to dynamo-electric machines." H. H. Lake. (Communicated by E. Thomson, United States.) Dated October 2. (*Complete.*)

14149. "Improvements in and connected with dynamo-electric machines and electric motors." B. Wilcox. (Communicated by C. S. Bradley, United States.) Dated October 2.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1887.

12763. "Improvements in electric meters or apparatus for measuring electricity." G. FORBES. Dated September 20. 8d. Is founded on the fact that an electric current passing through a conductor of electricity generates heat. This heat is applied to evaporate a liquid and from the quantity of the liquid so evaporated the quantity of electricity which has passed through the conductor is estimated. The claims are 3 in number.

13207. "Improvements in indicators for electric bells." A. MORLEY and H. W. WILSON. Dated September 29. 8d. Claims:—1. An indicator for electric bells, consisting essentially of an electromagnet of soft cast iron, japanned for insulation, wound with covered wire, and formed suitable for fixing and for attachment thereto of a spring armature or a spring with armature and of a "flag" substantially as set forth. 2. The construction of indicator described with reference to the drawing.

13320. "Improvements in electric regulators." J. G. STATTER and S. L. BRUNTON. Dated October 1. 8d. Consists of apparatus for automatically controlling and altering the position of the brushes on the commutator of dynamo-electric machines, whether generators, motors, or what are known as continuous current transformers, so as either alone or in conjunction with other devices or expedients to regulate their action in accordance with the circumstances required. That is to say to regulate in the case of a generator the strength $\frac{\text{and}}{\text{or}}$ the electromotive force of the current produced in accordance with the variations of the conditions of the circuit fed by such generator and in accordance with the variations of speed at which it is driven, and in the case of a motor to vary its speed in accordance with the variations in the conditions of the current with which it is fed or *vice versa* to maintain its speed constant independently of varying conditions of the feeding current. The claims are 6 in number.

13333. "Improvements in secondary generators, transformers, or converters of electricity." J. D. GIBBS and E. FESQUET. Dated October 1. 8d. The secondary circuit is formed of a continuous insulated copper wire or flat ribbon rolled on a mandrel in a lathe or otherwise. The length of this wire or ribbon is proportionate to the tension required by the lamps or other translating devices, and its section should be such that it will support without undue heating the desired quantity of current for the maximum number of lamps or other translating devices which the apparatus has to supply. The primary circuit consists of two coils united in series, each formed of a continuous insulated wire which may be rolled on a mandrel in a lathe or otherwise. The coils, after having been rolled are placed one inside the other, the secondary coil being inside and insulated from both sides of the primary which may be effected by an air space. The primary coils, both outside and inside, as well as at the points where the iron core are fixed, are covered with insulating material, to prevent any contact between the coils and the iron core. The iron core is next placed on the coils, and this is very rapidly effected, as the said core consists of very thin plates of soft iron of [shape, the metallic surface on one side being bare, and the other side having secured to it, by gumlac or otherwise, a thickness of paper or equivalent material. The said plates are placed one on one side of the coils, and the other on the other side, so that two consecutive plates touch each other with their bare metallic surfaces, forming a closed magnetic field, surrounding the two circuits. The two following plates form another closed magnetic field, but they are magnetically insulated from the field on either side by the thicknesses of paper or equivalent material. When the requisite number desired of plates is in place the apparatus is placed in a cast iron box of two pieces, and the whole may be securely fastened by a bolt through the centre. These cast iron boxes have projections or mouldings on an inclined plane, which projections or mouldings fit into the interval left open by the iron sheets, and when the central bolt is tightened these projections or mouldings press the iron plates together, and thus prevent noise which might otherwise be caused by vibrations, insuring at the same time a perfect contact between the plates. When the apparatus is required for use in the open air the aforesaid box should be hermetically closed. The claims are 4 in number.

13510. "Improvements in microphones." W. GENEST. Dated October 5. 8d. The inventor subjects the contacts to a certain breaking action, so that the pressure wherewith the movable part of the contact is pressed against, the one on the diaphragm is only dependent upon the adjustable pressure or tension of a spring, and the pressure of contact hence is made more or less independent of gravity. The claims are 2 in number.

CORRESPONDENCE.

The Phonograph and Graphophone.

Perhaps you will allow me to make one or two remarks in reference to your editorial on the above subject, contained in your issue for the 5th inst.

In the first place it is no doubt perfectly true that Edison's claim to the original phonograph has never been seriously contested, and for the mere conception of such a very remarkable and beautiful instrument, crude though it was, he certainly deserves infinite credit. This, I believe, nearly every one allows, but the complaint of the promotors of the graphophone against Mr. Edison is, I believe, not that the original phonograph was not his own invention, but that the recent improvements in the instrument which have rendered it for the first time of practical utility even though this utility be limited, improvements which are entirely due to the researches and experiments of the scientists composing the Volta Graphophone Association, have been made use of in Mr. Edison's new phonograph without any acknowledgment.

It is difficult to see what tribunal but the Law Courts can decide whether this contention is the case or not, but it is certainly a remarkable fact that Mr. Edison allowed all his original English phonograph patents to lapse, and did practically nothing to make the instrument of practical utility till the Graphophone Association had shown him that this could be done, and that he then adopted precisely the same record material—wax—that they were using. With regard to the remainder of your remarks, it appears to me that you to some extent fall into the error of assuming the ultimate capabilities of the phonograph—I use the word to cover both instruments—to be limited to its existing capabilities in its present form.

It should be remembered that for several years after its invention the telephone was looked upon as a toy of no practical commercial utility, and that such has been the case with more than one of the inventions that have made the nineteenth century what it is.

There does not seem to be any insuperable difficulty in the way of a machine for copying phonographic records, or of making them in duplicate in the first instance.

If impressed on a flat surface instead of the present cylinder, and on some material of greater flexibility and durability than wax, phonographic records could be as easily filed and as easily transmitted by post as are ordinary letters, and it is not to be supposed that anything like the limit has yet been attained in the way of impressing as large an amount of conversation as can be got on a surface of given area.

The most real difficulty in connection with the instrument's universal application to correspondence seems to me to lie in the fact that a phonographic record prepared by an instrument can only be reproduced from an instrument of precisely similar pattern, which will lead to great confusion when—as must utimately be the case—there are many different patterns of the instrument in the market, made by different makers. If it were not for the paralysing effect that such a thing seems always to have on improvement, it is almost a case in which an absolute monopoly would be positively beneficial.

We are not very likely to see a phonographic monopoly, but in any case there is not much reason for doubt that in, say, five years time phonographs will be very different from what they are to-day.

A. A. Campbell-Swinton.

October 10*th*, 1888.

Lightning.

I feel the letter of Prof. Lodge in your last issue requires some notice. I hope he will not be offended by my saying the reply he has been good enough to give to my query seems to partake rather of the nature of an assertion than an explanation. It is really no answer to simply refer me (which in effect he does) to my own illustrations, and to say "A released pendulum or a spring represents the whole thing exactly; there is no mystery in the matter."

I myself referred at some length to the pendulum and the spring as the two examples of oscillation we are acquainted with, coming to the conclusion from the evidence they afforded that oscillations were a consequence of the storage of force by matter, and I stated I had treated the subject at some length because I wished to emphasise (what appears to me) the fact that oscillations involve matter, and I asked would it be too much to suggest that "If there be such a thing as electric oscillations matter must be concerned in them." Now I can hardly lay the flattering unction to my soul that I have converted Prof. Lodge to my own views. First, because if such were the case I am sure he would say so, and, secondly, the reasoning on what was observed in the case of pendulum oscillations led me incidentally to conclusions opposed to those which Prof. Lodge considers to have been abundantly proved, and for which he is able to claim the support of the most able mathematical scientists.

I am sorry to find my criticisms would appear to have given offence. Prof. Lodge says I have implied "That in general he is accustomed to fit facts to a preconceived theory;" and he further says—"To this tone I have a right to object, and I do object." The sentence in my article complained of reads as follows: "Able as they are (I here allude to the two lectures, and the articles on "Modern Views of Electricity") there is a tendency to fit the facts to the theory being championed."

I am very sorry I did express my honest convictions so frankly, but that I am sorry is simply because it has given offence where no offence was intended, and has led to a side issue being raised, wich I regret *exceedingly*.

In both the letters of Prof. Lodge side issues have been raised, and no attempt has been made to refute the reasoning very fully given in my article, which leads me to conclusions very much opposed to those receiving the support of Prof. Lodge.

After all, it is a small matter whether I have been guilty of bad form or not, but whether I have promulgated truth or error is of some importance, and I should have been glad if Prof. Lodge had condescended to have given some expression of his views in reference to what I had brought forward, instead of confining his remarks almost entirely to side issues. Much of what I have stated is a question of downright fact. Either I am right or I am wrong. For example, take the "Alternative Path Experiment." Prof. Lodge generalises on the results he obtained, I think, somewhat hastily, and has arrived at conclusions opposed to those hitherto generally held by electricians. I have analysed this experiment, and pointed out that from the way in which it was tried—first, that there is considerable induction between the long length of wire which formed the alternative route, the walls of the room and the opposite sides of the loop; and, secondly, that with such high potentials as were employed in these experiments electricity will discharge into the atmosphere. Now I venture to believe no one will deny my premises to be sound, whatever may be the view taken of the conclusions I arrive at; but if my view be the right one, there is afforded a common sense explanation of what was actually observed, for, as a consequence of the greater magnetic inertia of iron, as well as the very much greater electrical resistance of the alternative route when it was formed of fine iron wire, the tendency to discharge through the atmosphere would be increased, and, as I stated, if the experiment were performed in a darkened room, I believe there would be seen a visible discharge into the atmosphere.

I feel I ought briefly to refer to the tinfoil spiral experiment which Prof. Lodge considers I have criticised a little unfairly; and, as I do not want to go over the same ground again, I would ask any of your readers who may feel an interest in the matter to refer back to your journal of September 21st where I have criticised this experiment at considerable length. In this particular experiment a bundle of fine iron wires was inserted in the interior of a glass tube wrapped spirally with a ribbon of tinfoil 21 feet long and insulated with three layers of paraffined paper. Leyden jar discharges were sent through the tinfoil spiral, and it was found that the critical length of the B spark was the same whether the iron core was inserted at the time of discharge or not, that is to say, the rate of discharge was not influenced in any way by the insertion of the bunde of iron wires.

Prof. Lodge remarks on what was observed, and says, referring to the permeability of iron to magnetism, "Here it is becoming virtually no bigger than that of air." He then observes on the established fact that a knitting needle can be magnetised by passing a Leyden discharge round it, and recognises it is opposed to the results obtained in his similar experiment, performed on a somewhat larger scale, and remarks, "Here are points requiring further examination." That further examination was required appears to me to be self evident, and had I performed this experiment I should at once have suspected the insulation was not sufficient. I speak with a certain amount of experience on such matters as insulation, for I was the first to make paper condensers which would hold a statical charge for a considerable length of time, and to suggest the costruction of artificial submarine circuits, a minute description of which was published in the Society of Arts Proceedings of 1859.

To make paper insulate it is absolutely necessary to dessicate it completely by heating it to a temperature of about 300 F. before dipping it in the melting paraffine. Paper so dried becomes brittle. It is possible the precaution to thoroughly dessicate the paper was not taken. In any case the paraffine would be liable to crack, and three layers of paper would be a poor insulation for high tension statical discharges, and therefore it is not at all improbable the insulation may have broken down.

My contention is you cannot send a current round a mass of iron without doing work of some kind, and such work checks and delays a statical discharge. I follow the reasoning of Lord Rayleigh, which is, in effect, that electricity was produced instead of magnetism. I have pointed out in my criticism that where electricity is produced *instead* of magnetism, as in transformers for example, there is, comparatively speaking, only a small check to the passage of the electric current through the primary wire; but where there is no secondary circuit in which electricity can be developed as in the tinfoil spiral experiment, the conditions presented by a bundle of iron wires are just those which are the least favourable for the development of electricity instead of magnetism, and taking into consideration the fact that a knitting needle which presents conditions less favourable for the development of magnetism by a statical discharge can be magnetised by means of a Leyden jar, I am of opinion that if the experiment with the fine iron wires inside the glass tube was repeated with much thicker insulations a different result would be obtained.

There is another explanation which might explain what was observed, and which is opposed to the view for which I have been contending, viz., that the secondary, or Foucault, current developed was so intense that the current leapt across from wire to wire, the bundle behaving as a solid mass of iron; but the knitting needle experiment seems to dispose of such a suggestion.

S. Alfred Varley.

October 4th, 1888.

"What is Electricity?"

I gather from Mr. Preece's letter that he applies the term "electricity" not to the value measured by $\frac{E}{R^c}\times$ time, in electro-dynamics, and by $\frac{E}{2R^i}$* in electro-statics, but to the value measured by Q E (volt coulombs), or, what is the same thing, by C E × time (watt seconds). This being the case, it must, of course be conceded that Mr. Preece's "electricity" is a mode of energy. But the question still remains as to the nature of the former value—that which has been termed "electrical quantity," or simply "electricity," by everybody, so far as I am aware, excepting Mr. Preece.

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* R^c stands for conductive, and R^i for inductive, resistance.

As a very old antagonist of Mr. Preece in relation to the views propounded by him as to the nature of "electricity," it appears to me rather a *mauvaise plaisanterie* on his part to have delayed so long the explanation that when he spoke of "electricity" he meant "electrical energy." And it would seem that this explanation requires further amplification. Seventeen years ago Mr. Preece maintained, as susceptible of proof, that "electricity is a peculiar *force* affecting the particles of matter." He affirmed, moreover, that this was "the doctrine taught by Helmholtz, Thomson, and our masters in this department of science." I should mention that it was explained at the time that he used the term "force" in the same general sense in which he used the term "matter." Should it not have been explained, or was it intended to explain, that when he spoke of "force" he meant "energy?"

I think Mr. Preece inadvertently misrepresented the views of "our masters in science," and I think with you, Sirs, that he has, more recently, misrepresented the views of electrical engineers generally. I think, also, that prior to the explanations given in your columns he was misrepresenting his own view. One great master in science—Clerk Maxwell—whose view has never been disproved, states that:—"The quantities, 'electricity' and 'potential,' when multiplied together, produce the quantity 'energy.' It is impossible, therefore, that electricity and energy should be quantities of the same category; for electricity is only one of the factors of energy." The electrical engineer knows perfectly well that ampère-hours express quantity of electricity, and that their value depends upon the pressure under which they are supplied. He does not require that the analogy between "electricity" and vapour at atmospheric pressure, or water at the sea-level, should be pointed out to him. All of which is pithily expressed in your paragraph on p. 330. But Mr. Preece, by stating that electricity is energy, without either adhering to established definitions, or giving definitions of his own (a proceeding which I would deprecate) has mystified the electrical public (and caused me in past years to write many columns) by allowing it to be supposed that—with all his experience and technical knowledge—he considered $\frac{E}{R}\,\theta$ to be a mode of energy, and required that analogies such as the above should be insisted upon in opposition to his views.

Desmond G. Fitzgerald.

Earthing the Secondary.

I notice in your issue of September 7th, 1888, a letter signed "Trans-Atlantic." The statement occurs in the letter with respect to the earthing of secondaries, as proposed by me, as follows:—"His main purpose, however, was not the protection of human life, but to enable the engineer of the central lighting station to detect any short circuits between the primary and secondaries in transformers."

This is decidedly not true, and I do not know where "Trans-Atlantic" gets his authority for the statement. Certainly not from myself, as the main purpose was, emphatically, the protection of human life, and not only was earthing of the secondaries proposed for that purpose chiefly, but the insulated metallic shield between the primary and secondary, which your correspondent, "Trans-Atlantic," says some companies in the United States put between the primary and secondary, was at the same time proposed along with the earthing of the secondary, and both patented at the same time in the United States.

I am decidedly of the opinion that either of these safety arrangements are effective for the purpose of preventing injury to persons in case a contact should be formed between the primary and secondary of a transformer. I have devised other methods of protection which I consider almost equally effective, and which are not ready for publication.

It would have been much better if "Trans-Atlantic" had taken the pains to read my United States patent, No. 322,138, before so dogmatically attributing to me a purpose which was not my purpose. In fact, I am at a loss to understand how he could have known what my purpose was except by reference to the published description or to the patent itself, both of which are perfectly clear on the point at issue. Perhaps "Trans-Atlantic" may be able to explain how a statement which could only have arisen in his imagination comes to be quoted as an actual fact, and so mislead your readers, and, further, I decidedly object to his free and easy way of attributing to me any purpose with which he is not conversant.

Elihu Thomson.
Per J. W. G.

Lynn, Mass., *September 26th*, 1888.

Jointing Underground Cables.

I can endorse Mr. E. W. Beckingsale's statement as to using other ways of connecting mains and branches than by splicing, for when at Leamington we used large cables, and I found it took a jointer and labourer five hours at a cost of 5s. each joint. This I found could be done much cheaper and better by using a clip or pipe and running them together solid. At the time I gave Mr. F. Thornton, the residental engineer, some drawings of the connectors or clips I proposed, which I believe was forwarded to Mr. A. Chamberlain, but was told to make a joint other than by splicing was of no good, and so my idea and drawings were knocked on the head. As I have tried this kind of connecting on other mains with a good result I am pleased to read that Mr. E. W. Beckingsale has tried it with success.

Hy. Albert.

October 6th, 1888.

The Sun Lamp.

I am glad to see, from your leader in last week's edition, that there is a likelihood of the "Sun" lamp being introduced in an improved form. All users of the electric light who have seen the beautiful light it gives must have regretted its previous imperfections in working. I am also glad to see the remarks at the end of the same article, and, as you say, hope it will be put before the users of electricity in a business-like form, and not by means of a huge company, of which we have seen so many failures in matters connected with the electric light.

"An Old User of Arc and Incandescents."

October 8th, 1888.

Electrolysis by Alternating Currents.

The enclosed specimen of the electrolytic action of alternating currents was prepared in the following way:—

The piece of white blotting paper was first dipped in a perfectly clear solution of iodide of potassium. The top letters were written with a pointed electrode joined up with the so-called positive pole of a secondary coil wound with many turns of fine wire. The bottom letters were written when the electrode was connected with the pseudo-negative pole of the secondary coil. The vibrations were over 100 per second.

Knowing exactly the amount of electrical knowledge possessed by the "eminent" authority quoted in your last issue, comments would only be wasted.

William Lynd.

[The piece of blotting paper which our correspondent sends has traced upon it the letters E.R., which are still quite distinct.—Eds. Elec. Rev.]